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CONTENTS

A NOTE ON THE PHARMACOLOGICAL ACTION OF *SCILLA COOPERI*, HOOK. FIL., *SCILLA ROGERSII*, BAKER, and *SCILLA LANCEAEFOLIA*, BAKER.

By J. W. C. Gunn, Morris Goldberg, and J. H. Ferguson.

(From the Department of Pharmacology, University of Cape Town.)

Several plants of the natural order of Liliaceae are known to have the pharmacological action of the "digitalis group." Squill, *Scilla maritima* or *Urginea scilla*, has been used in medicine for a long time. *Urginea indica* is used in India and the East. One of us (1) has shown that the South African plant, *Urginea burkei*, Baker, has the same qualitative and quantitative actions as the official squill. This plant was subsequently tried in a few cases of auricular fibrillation by Professor A. W. Falconer, and he found it to be as good as, but to have no advantages over, the better-known drug, digitalis.

An unidentified bulb, examined in this department, was found to be even more active. *Scilla rigidifolia* did not show the usual digitalis action. Its main action was to cause a marked, and usually prolonged, fall of blood-pressure, followed sometimes by a rise above the normal. It may, however, contain a digitalis body, whose action is masked by some depressor substance. (Observations not yet published.)

We received from Professor R. H. Compton, Botanical Gardens, Kirstenbosch, specimens of three other South African varieties of Scilla, namely, *Scilla cooperi*, Hook. fil., *Scilla rogersii*, Baker, and *Scilla lanceaefolia*, Baker. It is a matter of interest to know if the many varieties of Scilla, grown in different parts of the world, possess the digitalis action. If one were found to be very active, it might become important medicinally. The present research was therefore undertaken to investigate the action of these three plants, and to compare their toxicity.

Method.

The bulbs were cut into slices, dried, and powdered. A 20 per cent. tincture was prepared according to the British pharmacopœial method for the official bulb. The tincture was used in the experiments, the alcohol

being driven off and replaced by an equal amount of normal saline solution before use. On being boiled with a dilute acid, the alcohol-free tincture liberates glucose or some other Fehling-reducing substance. It is probable, therefore, that the active principles, as in most of the plants which act like digitalis, are glucosidal.

Experiments were performed on the isolated heart (frog and cat), heart *in situ* (frog, cat, and dog), blood-pressure and intestinal volume (cat), excised uterus and intestine (rabbit and cat), and on the intact animal (frog, cat, and rat), by subcutaneous injection. The methods were the same as those described in the former paper (1).

Results.

(a) *Action.*

These experiments showed that the three varieties of squill have the typical action of the digitalis group. The frog's heart was arrested with the ventricle in complete systole and the auricles dilated. The excised mammalian heart stopped in systole. Most of the irregularities described by Cushny (2) were seen in the mammalian heart *in situ*; fibrillation of the ventricle being the usual fatal termination. With the larger doses there was a considerable rise of blood-pressure, due partly to constriction of the splanchnic vessels, but mainly to the cardiac effect.

(b) *Toxicity.*

The amount of material at our disposal (in each case, under 18 grms. of the dried bulb) was insufficient to determine the minimal lethal dose for mammalia. We therefore employed the one-hour frog method (estimation of the dose, per grm. of frog weight, which will arrest the heart in one hour) which is commonly used in the biological assay of these drugs. *Xenopus laevis* was used in these tests, its reaction being quantitatively the same as *Rana* (3).

The minimal one-hour systolic doses per grm. of frog were :—

Scilla rogersii	0·0055 c.c.
Scilla lanceaefolia	0·08 ,,
Scilla cooperi	0·02 ,,

The accepted standard for Tinctura Scillae B.P. is 0·006 c.c. *Scilla rogersii* is therefore as active as the official plant, but the other two are considerably weaker. The first plant might be cultivated in South Africa and used in place of the *Urginea scilla* of the British Pharmacopœia. For

this purpose it would probably be no better than *Urginea burkei*, which grows wild and in abundance. It is, however, extremely unlikely that any plant of this series, unless it possesses very apparent advantages, will ever displace, or even prove a rival to, digitalis.

Summary.

The three South African varieties of Scilla discussed in this paper have the action of the digitalis group. Only one, *Scilla rogersii*, is as active as *Urginea scilla*.

References.

(1) J. W. C. Gunn.—Trans. Roy. Soc. S. Afr., vol. ix, p. 197, 1921.
(2) A. R. Cushny.—Journ. Exp. Med., vol. ii, p. 234, 1897.
(3) J. W. C. Gunn.—Trans. Roy. Soc. S. Afr., vol. x, p. 55, 1921.

NOTE ON SYSTEMS OF DETERMINANTS WITH SETS OF DELETED ELEMENTS.

By Sir Thomas Muir, F.R.S.

1. If Δ stand for $| \, a_1 b_2 c_3 \, |$, and from the first Δ in the identity

$$\Delta + \Delta + \Delta = 3\Delta$$

we delete a_2, from the second b_2, and from the third c_2, thus removing from the left-hand side

$$a_2 A_2 + b_2 B_2 + c_2 C_2 \text{ i.e. } \Delta,$$

we manifestly have

$$\begin{vmatrix} a_1 & \cdot & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix} + \begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & \cdot & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix} + \begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & \cdot & c_3 \end{vmatrix} = 2\Delta,$$

and we see the truth of the simple theorem : *If $\Delta_{(1)}$ be a determinant got from an* n*-line determinant Δ by deleting an element in a fixed row (or column), then*

$$\sum \Delta_{(1)} = (n-1)\Delta.$$

From this we may be led to think of deleting p elements instead of 1, and thereafter to take still another step forward, the ultimate result being the formulating of the theorem : *If $\Delta_{(p)q}$ be a determinant got from an* n*-line determinant Δ by taking* p *fixed rows, and in this* n*-by-*p *array zero-ising any* q *columns, then*

$$\sum \Delta_{(p)q} = (n-p)_q \Delta$$

where $(n)_r$ stands for $n(n-1)\ldots(n-r+1)/r\,!$

2. Further, if so minded, we might deduce therefrom the equality

$$\sum \Delta_{(p),0} - \sum \Delta_{(p),1} + \;\ldots\; + (-1)^{n-p} \sum \Delta_{(p),n-p} = (1-1)^{n-p}\Delta = 0$$

—a fact of no consequence save perhaps as illustrating the type to which belongs Frobenius' double-sigma theorem in determinants which we

commented on two years ago in the Proceedings of the Royal Society of Edinburgh, xlii, pp. 342–347.*

3. Of greater interest is the question of the effect produced by substituting in place of the zeros in $\Delta_{(p),q}$ non-zero quantities taken from an external source, the substitution being such that any one of the latter shall always occupy the same place. For example, when $\Delta = | a_1b_2c_3d_4 |$ and the non-zero external quantities are

$$t_1, t_2, t_3, t_4,$$

$\sum\Delta_{(1),2}$ becomes on substitution

$$\begin{vmatrix} a_1 & a_2 & t_3 & t_4 \\ b_1 & b_2 & b_3 & b_4 \\ \cdots & \cdots & \cdots & \cdots \end{vmatrix} + \begin{vmatrix} a_1 & t_2 & a_3 & t_4 \\ b_1 & b_2 & b_3 & b_4 \\ \cdots & \cdots & \cdots & \cdots \end{vmatrix} + \cdots\cdots + \begin{vmatrix} t_1 & t_2 & a_3 & a_4 \\ b_1 & b_2 & b_3 & b_4 \\ \cdots & \cdots & \cdots & \cdots \end{vmatrix}$$

which

$$=3 \mid a_1b_2c_3d_4 \mid +3 \mid t_1b_2c_3d_4 \mid .$$

We thus arrive at the theorem : *If* D *stand for any* n*-line determinant, and* D_q *for what* D *becomes when* q *elements of its first row are changed into the corresponding elements of the new row* $t_1, t_2, \ldots, t_n$, *then*

$$\sum D_q = (n-1)_q D + (n-1)_{q-1} D_n.$$

4. The subject has a bearing on Laplace's expansion-theorem, for which, indeed, it enables us to produce two useful variant forms.

5. If the said expansion of an n-line determinant be in terms of r-line minors and their complementaries, the $(n)_r$ terms of the expansion naturally partition themselves into $r+1$ sets, in accordance with the equality

$$(n)_r = (r)_r + (n-r)_1(r)_{r-1} + (n-r)_2(r)_{r-2} + \ \ldots \ + (n-r)_r.$$

For example, if n be 7 and r be 3, the determinant being

$$| a_1b_2c_3d_4e_5f_6g_7 |, \text{ or } \Delta \text{ say,}$$

and the first factors of the terms of the expansion being taken from the first 3 rows, we shall have 4 kinds of terms, differentiated from one another by the number of columns which they have in common with the array

$$\begin{matrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{matrix} ;$$

* Anyone who may have been interested in this commentary might care to know of four papers that followed it up, namely, by Rice, L. H., in Bull. American Math. Soc., xxix, p. 153 ; Lecat, M., in Comptes Rendus . . . (Paris), clxxvi, pp. 972–975 ; Lecat, M., in Ann. . . . Soc. sci. de Bruxelles, xlii (1), pp. 322–329 ; Rice, L. H., in Mass. Inst. of Tech. ; Math. and Phys., iii, pp. 118–126.

namely,

1 term	with	three	columns	in common.
12 terms	,,	two	,,	,,
18 ,,	,,	one	column	,,
4 ,,	,,	no	,,	,,

The Laplace expansion-formula may thus be written

$$
\begin{aligned}
|\, a_1b_2c_3d_4e_5f_6g_7 \,| = |\, a_1b_2c_3 \,|\,|\, d_4e_5f_6g_7 \,| + \sum |\, a_1b_2c_4 \,|\,|\, d_3e_5f_6g_7 \,| \\
+ \sum |\, a_1b_4c_5 \,|\,|\, d_2e_3f_6g_7 \,| + \sum |\, a_4b_5c_6 \,|\,|\, d_1e_2f_3g_7 \,| .
\end{aligned}
$$

6. Now the set of 12 terms here can be recondensed into the 3

$$
\begin{vmatrix}
a_1 & a_2 & \cdot & a_4 & a_5 & a_6 & a_7 \\
b_1 & b_2 & \cdot & b_4 & b_5 & b_6 & b_7 \\
c_1 & c_2 & \cdot & c_4 & c_5 & c_6 & c_7 \\
\cdot & \cdot & d_3 & d_4 & d_5 & d_6 & d_7 \\
\cdot & \cdot & e_3 & e_4 & e_5 & e_6 & e_7 \\
\cdot & \cdot & f_3 & f_4 & f_5 & f_6 & f_7 \\
\cdot & \cdot & g_3 & g_4 & g_5 & g_6 & g_7
\end{vmatrix}
+
\begin{vmatrix}
a_1 & \cdot & a_3 & a_4 & a_5 & a_6 & a_7 \\
b_1 & \cdot & b_3 & b_4 & b_5 & b_6 & b_7 \\
c_1 & \cdot & c_3 & c_4 & c_5 & c_6 & c_7 \\
\cdot & d_2 & \cdot & d_4 & d_5 & d_6 & d_7 \\
\cdot & e_2 & \cdot & e_4 & e_5 & e_6 & e_7 \\
\cdot & f_2 & \cdot & f_4 & f_5 & f_6 & f_7 \\
\cdot & g_2 & \cdot & g_4 & g_5 & g_6 & g_7
\end{vmatrix}
+
\begin{vmatrix}
\cdot & a_2 & a_3 & a_4 & a_5 & a_6 & a_7 \\
\cdot & b_2 & b_3 & b_4 & b_5 & b_6 & b_7 \\
\cdot & c_2 & c_3 & c_4 & c_5 & c_6 & c_7 \\
d_1 & \cdot & \cdot & d_4 & d_5 & d_6 & d_7 \\
e_1 & \cdot & \cdot & e_4 & e_5 & e_6 & e_7 \\
f_1 & \cdot & \cdot & f_4 & f_5 & f_6 & f_7 \\
g_1 & \cdot & \cdot & g_4 & g_5 & g_6 & g_7
\end{vmatrix}
$$

which we may denote by ΣP_2; and the set of 18 terms into the 3

$$
\begin{vmatrix}
a_1 & \cdot & \cdot & a_4 & a_5 & a_6 & a_7 \\
b_1 & \cdot & \cdot & b_4 & b_5 & b_6 & b_7 \\
c_1 & \cdot & \cdot & c_4 & c_5 & c_6 & c_7 \\
\cdot & d_2 & d_3 & d_4 & d_5 & d_6 & d_7 \\
\cdot & e_2 & e_3 & e_4 & e_5 & e_6 & e_7 \\
\cdot & f_2 & f_3 & f_4 & f_5 & f_6 & f_7 \\
\cdot & g_2 & g_3 & g_4 & g_5 & g_6 & g_7
\end{vmatrix}
+ \ldots\ldots, \text{ or } \sum P_1 \text{ say,}
$$

and the set of 4 terms into

$$
\begin{vmatrix}
\cdot & \cdot & \cdot & a_4 & a_5 & a_6 & a_7 \\
\cdot & \cdot & \cdot & b_4 & b_5 & b_6 & b_7 \\
\cdot & \cdot & \cdot & c_4 & c_5 & c_6 & c_7 \\
d_1 & d_2 & d_3 & d_4 & d_5 & d_6 & d_7 \\
\cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot
\end{vmatrix}
, \text{ or } \sum P_0 \text{ say;}
$$

so that a variant form of the expansion-formula is

$$
\Delta = P_3 + \sum P_2 + \sum P_1 + \sum P_0 .
$$

7. If instead of the first 3 rows of Δ in the foregoing we had taken the first 3 columns from which to form the 3-line minors of the expansion, we should have found

$$\Delta = |\,a_1b_2c_3\,||\,d_4e_5f_6g_7\,| + \sum |\,a_1b_2d_3\,||\,c_4e_5f_6g_7\,| + \sum |\,a_1d_2e_3\,||\,b_4c_5f_6g_7\,| + \sum |d_1e_2f_3\,||\,a_4b_5c_6g_7|$$

$$= \begin{vmatrix} a_1 & a_2 & a_3 & . & . & . & . \\ b_1 & b_2 & b_3 & . & . & . & . \\ c_1 & c_2 & c_3 & . & . & . & . \\ d_1 & d_2 & d_3 & d_4 & d_5 & d_6 & d_7 \\ e_1 & e_2 & e_3 & e_4 & e_5 & e_6 & e_7 \\ f_1 & f_2 & f_3 & f_4 & f_5 & f_6 & f_7 \\ g_1 & g_2 & g_3 & g_4 & g_5 & g_6 & g_7 \end{vmatrix} + \begin{vmatrix} a_1 & a_2 & a_3 & . & . & . & . \\ b_1 & b_2 & b_3 & . & . & . & . \\ . & . & . & c_4 & c_5 & c_6 & c_7 \\ d_1 & d_2 & d_3 & d_4 & d_5 & d_6 & d_7 \\ e_1 & e_2 & e_3 & e_4 & e_5 & e_6 & e_7 \\ f_1 & f_2 & f_3 & f_4 & f_5 & f_6 & f_7 \\ g_1 & g_2 & g_3 & g_4 & g_5 & g_6 & g_7 \end{vmatrix} + \ldots\ldots$$

$$= Q_3 + \sum Q_2 + \sum Q_1 + \sum Q_0, \text{ say.}$$

Now Q_3 and ΣQ_0 are manifestly the same as P_3 and ΣP_0 respectively: and thus we have

$$\sum Q_2 + \sum Q_1 = \sum P_2 + \sum P_1.$$

A little investigation, however, shows that this is not all—that, in fact, we have here lit on the rather important result

$$\sum Q_m = \sum P_m$$

for all relevant values of m.

To see how this arises let us take from ΣQ_2 a manifest term of the Laplace expansion, $|\,a_1b_2g_3\,||\,c_4d_5e_6f_7\,|$, say, and then returning to the P expansion try to ascertain its place there. Without trouble we find that the second factor of it, $|\,c_4d_5e_6f_7\,|$, is a minor in every one of the P's, and that therefore what we have got to do is to ascertain the cofactor of $|\,c_4d_5e_6f_7\,|$ in each P. The outcome of this is that the cofactor in ΣP_2 is

$$\begin{vmatrix} a_1 & a_2 & . \\ b_1 & b_2 & . \\ c_1 & c_2 & g_3 \end{vmatrix} + \begin{vmatrix} a_1 & . & a_3 \\ b_1 & . & b_3 \\ c_1 & g_2 & c_3 \end{vmatrix} + \begin{vmatrix} . & a_2 & a_3 \\ . & b_2 & b_3 \\ g_1 & c_2 & c_3 \end{vmatrix}$$

and that elsewhere it is 0. The equality of ΣQ_2 and ΣP_2 is thus seen to be a consequence of the simple theorem with which we began. The general result when properly formulated is: *If an* n*-line determinant be expanded in terms of the* k*-line minors of the first* k *rows and their complementary minors, and* ΣP_h *be the aggregate of the terms of the expansion that have* h *columns in common with the first* k*-line minor of all, and if* ΣQ_h *be the corresponding aggregate when the first* k *columns take the place of the first* k *rows, then*

$$\sum P_h = \sum Q_h.$$

Further insight into the grounds for this will be obtained presently.

8. Returning to § 6 let us examine more closely the expansion-formula

$$\Delta = P_3 + \sum P_2 + \sum P_1 + \sum P_0,$$

beginning with the three six-line determinants composing ΣP_2. Clearly the first of these

$$= |a_1 b_2| \cdot \begin{vmatrix} \cdot & c_4 & c_5 & c_6 & c_7 \\ d_3 & d_4 & d_5 & d_6 & d_7 \\ e_3 & e_4 & e_5 & e_6 & e_7 \\ f_3 & f_4 & f_5 & f_6 & f_7 \\ g_3 & g_4 & g_5 & g_6 & g_7 \end{vmatrix} - |a_1 c_2| \cdot \begin{vmatrix} \cdot & b_4 & b_5 & b_6 & b_7 \\ d_3 & d_4 & d_5 & d_6 & d_7 \\ \cdot & \cdot & \cdot & \cdot & \cdot \end{vmatrix} + |b_1 c_2| \cdot \begin{vmatrix} \cdot & a_4 & a_5 & a_6 & a_7 \\ d_3 & d_4 & d_5 & d_6 & d_7 \\ \cdot & \cdot & \cdot & \cdot & \cdot \end{vmatrix},$$

and the second and third are similarly developable, giving us in all 9 terms, each having for the first factor a primary minor of $| a_1 b_2 c_3 |$, and for the second the cofactor of this primary minor in Δ, save that the first element of the said cofactor is deleted. In like manner the three six-line determinants composing ΣP_1 give us 9 terms, each having for a first factor a secondary minor of $| a_1 b_2 c_3 |$, and for the second the cofactor of this secondary minor in Δ, save that the first two-line minor of the said cofactor is zero-ised. We thus have a new 20-term expansion of Δ, wherein each term has for a first factor a minor of $| a_1 b_2 c_3 |$ of the 3rd, 2nd, 1st, or 0th order, and for the second factor a partly zero-ised minor of Δ, namely

$$\Delta = | a_1 b_2 c_3 | \cdot | d_4 e_5 f_6 g_7 | + \sum | a_1 b_2 | \cdot \begin{vmatrix} \cdot & c_4 & c_5 & c_6 & c_7 \\ d_3 & d_4 & d_5 & d_6 & d_7 \\ \cdot & \cdot & \cdot & \cdot & \cdot \end{vmatrix}$$

$$+ \sum a_1 \begin{vmatrix} \cdot & \cdot & b_4 & b_5 & b_6 & b_7 \\ \cdot & \cdot & c_4 & c_5 & c_6 & c_7 \\ d_2 & d_3 & d_4 & d_5 & d_6 & d_7 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{vmatrix} + \begin{vmatrix} \cdot & \cdot & \cdot & a_4 & a_5 & a_6 & a_7 \\ \cdot & \cdot & \cdot & b_4 & b_5 & b_6 & b_7 \\ \cdot & \cdot & \cdot & c_4 & c_5 & c_6 & c_7 \\ d_1 & d_2 & d_3 & d_4 & d_5 & d_6 & d_7 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{vmatrix}.$$

9. In the present connection it is the axisymmetry of this expansion that is the important feature: there is no sign of predominance of rows over columns or of columns over rows: and when we turn to the Q expansion and treat it as we have just treated the P expansion we are therefore not surprised to find the outcome in the two cases to be the same. On the surface this is due to the non-zero two-line minors of

$$\begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ \cdot & \cdot & \cdot \end{vmatrix}, \quad \begin{vmatrix} a_1 & a_2 & a_3 \\ \cdot & \cdot & \cdot \\ c_1 & c_2 & c_3 \end{vmatrix}, \quad \begin{vmatrix} \cdot & \cdot & \cdot \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix}$$

being the same as those of

$$\begin{vmatrix} a_1 & a_2 & . \\ b_1 & b_2 & . \\ c_1 & c_2 & . \end{vmatrix}, \quad \begin{vmatrix} a_1 & . & a_3 \\ b_1 & . & b_3 \\ c_1 & . & c_3 \end{vmatrix}, \quad \begin{vmatrix} . & a_2 & a_3 \\ . & b_2 & b_3 \\ . & c_2 & c_3 \end{vmatrix},$$

and to similar identities.

We are thus faced again with the equality

$$\sum P_h = \sum Q_h.$$

10. When the determinant to be expanded is of the $(2m)$th order, and the expansion is in terms of m-line minors (taken, say, from the first m rows), special properties may naturally be looked for. For one thing, an additional type of symmetry makes its appearance, there being a likeness between every first factor of the expansion and its cofactor, the one being got from the first m rows exactly as the other is got from the last m rows doubly reversed. In other words, the expansion $\begin{vmatrix} 1\ 2 \ldots . \ 2m \\ 1\ 2 \ldots . \ 2m \end{vmatrix}$ in terms of m-line minors is term-by-term the same as the corresponding expansion of $\begin{vmatrix} 2m, 2m-1, \ldots, 2, 1 \\ 2m, 2m-1, \ldots, 2, 1 \end{vmatrix}$.

11. As a preliminary to utilising this let us consider the following theorem: *If* E *be a* 2m-*line determinant, and* E_r *the determinant got from it by deleting the last* m *elements of the* r*th column, then*

$$E_1 + E_2 + \ldots + E_m = mP_m + (m-1)\sum P_{m-1} + \ldots + \sum P_1.$$

Taking the case where m is 3, and where, therefore, the left-hand member is

$$\begin{vmatrix} a_1 & a_2 & a_3 & a_4 & a_5 & a_6 \\ b_1 & b_2 & b_3 & b_4 & b_5 & b_6 \\ c_1 & c_2 & c_3 & c_4 & c_5 & c_6 \\ . & d_2 & d_3 & d_4 & d_5 & d_6 \\ . & e_2 & e_3 & e_4 & e_5 & e_6 \\ . & f_2 & f_3 & f_4 & f_5 & f_6 \end{vmatrix} + \begin{vmatrix} a_1 & a_2 & a_3 & a_4 & a_5 & a_6 \\ b_1 & b_2 & b_3 & b_4 & b_5 & b_6 \\ c_1 & c_2 & c_3 & c_4 & c_5 & c_6 \\ d_1 & . & d_3 & d_4 & d_5 & d_6 \\ e_1 & . & e_3 & e_4 & e_5 & e_6 \\ f_1 & . & f_3 & f_4 & f_5 & f_6 \end{vmatrix} + \begin{vmatrix} a_1 & a_2 & a_3 & a_4 & a_5 & a_6 \\ b_1 & b_2 & b_3 & b_4 & b_5 & b_6 \\ c_1 & c_2 & c_3 & c_4 & c_5 & c_6 \\ d_1 & d_2 & . & d_4 & d_5 & d_6 \\ e_1 & e_2 & . & e_4 & e_5 & e_6 \\ f_1 & f_2 & . & f_4 & f_5 & f_6 \end{vmatrix}$$

and obtaining our first factors from the first three rows in each case, we have

$$\begin{array}{lllllll} \text{cofactor of} & |a_1\, b_2\, c_3| = & |d_4\, e_5\, f_6| & + & |d_4\, e_5\, f_6| & + & |d_4\, e_5\, f_6| \\ \text{cofactor of} & -|a_1\, b_2\, c_4| = & |d_3\, e_5\, f_6| & + & |d_3\, e_5\, f_6| & + & 0, \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \text{cofactor of} & |a_1\, b_4\, c_5| = & |d_2\, e_3\, f_6| & + & 0 & + & 0, \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \text{cofactor of} & -|a_4\, b_5\, c_6| = & 0 & + & 0 & + & 0 \end{array}$$

and therefore the left-hand member $= 3P_3 + 2\Sigma P_2 + \Sigma P_1$.

12. Now from the symmetry referred to in § 10 it follows that there must be another sum equal to

$$3\,\mathrm{P}_3+2\sum \mathrm{P}_2+\sum \mathrm{P}_1,$$

namely,

$$\begin{vmatrix} f_6 & f_5 & f_4 & f_3 & f_2 & f_1 \\ e_6 & e_5 & e_4 & e_3 & e_2 & e_1 \\ d_6 & d_5 & d_4 & d_3 & d_2 & d_1 \\ \cdot & c_5 & c_4 & c_3 & c_2 & c_1 \\ \cdot & b_5 & b_4 & b_3 & b_2 & b_1 \\ \cdot & a_5 & a_4 & a_3 & a_2 & a_1 \end{vmatrix} + \begin{vmatrix} f_6 & f_5 & f_4 & f_3 & f_2 & f_1 \\ e_6 & e_5 & e_4 & e_3 & e_2 & e_1 \\ d_6 & d_5 & d_4 & d_3 & d_2 & d_1 \\ c_6 & \cdot & c_4 & c_3 & c_2 & c_1 \\ b_6 & \cdot & b_4 & b_3 & b_2 & b_1 \\ a_6 & \cdot & a_4 & a_3 & a_2 & a_1 \end{vmatrix} + \begin{vmatrix} f_6 & f_5 & f_4 & f_3 & f_2 & f_1 \\ e_6 & e_5 & e_4 & e_3 & e_2 & e_1 \\ d_6 & d_5 & d_4 & d_3 & d_2 & d_1 \\ c_6 & c_5 & \cdot & c_3 & c_2 & c_1 \\ b_6 & b_5 & \cdot & b_3 & b_2 & b_1 \\ a_6 & a_5 & \cdot & a_3 & a_2 & a_1 \end{vmatrix}.$$

The two sums are consequently equal—a result more interestingly stated in the form

$$\left.\begin{array}{r} a_1\mathrm{A}_1+b_1\mathrm{B}_1+c_1\mathrm{C}_1 \\ +a_2\mathrm{A}_2+b_2\mathrm{B}_2+c_2\mathrm{C}_2 \\ +a_3\mathrm{A}_3+b_3\mathrm{B}_3+c_3\mathrm{C}_3 \end{array}\right\} = \left\{\begin{array}{l} f_6\mathrm{F}_6+e_6\mathrm{E}_6+d_6\mathrm{D}_6 \\ +f_5\mathrm{F}_5+e_5\mathrm{E}_5+d_5\mathrm{D}_5 \\ +f_4\mathrm{F}_4+e_4\mathrm{E}_4+d_4\mathrm{D}_4 \,; \end{array}\right.$$

and, generally, *If each element of the first* m-*line minor of a* 2m-*line determinant be multiplied by its cofactor in the latter, and the sum of the products taken, the result is the same as would have been got by using the last* m-*line minor in place of the first.**

RONDEBOSCH, S.A.,
19th May 1924.

* In the paper referred to above in § 2 there is an inaccuracy in § 8 : for, the substitution there specified being made, the cofactor of $|\, c_1\, d_2\, e_3 \,|$ on the left is manifestly

$$\begin{vmatrix} a_4 & a_5 \\ b_4 & b_5 \end{vmatrix} - \begin{vmatrix} a_4 & a_5 \\ u & v \end{vmatrix} - \begin{vmatrix} x & y \\ b_4 & b_5 \end{vmatrix} + \begin{vmatrix} x & y \\ u & v \end{vmatrix}$$

$$\textit{i.e.}\ \begin{vmatrix} a_4-x & a_5-y \\ b_4-u & b_5-v \end{vmatrix}.$$

Further details regarding the correction are given in Professor Rice's second paper noted above.

THE SMALLER SOUTH AFRICAN SHELLS THAT HARBOUR CERCARIAE.

By F. G. Cawston, M.D. Cantab.

In searching pools for the intermediate hosts of trematode worms there is a tendency to overlook the smaller shells as immature examples of a larger species. Many of these are really mature examples of the species they represent, and it is a little surprising to find some of them infested with relatively large cercariae. The largest cercaria that has yet been reported from South Africa measures 2·45 mm. in total length, the tail being equal in length to that of the body. The cyst of this eye-spotted amphistome from the Umgeni mouth measures 0·4375 mm. in diameter. The cercaria occurs in a small *Planorbis* resembling *gibbonsi* Nelson, whose shell is seldom more than 5 mm. in diameter. Early infestation with a different cercaria was detected in an example of this *Planorbis* from the same pool; but the infection was too early to define with certainty. A similar *Planorbis* from a neighbouring pool on the course of the Umgeni, measuring only 3 mm. in diameter, was infested with a distome which measured 0·7 mm. in total length. The cercaria showed a well-developed acetabulum and may be the full-grown cercaria referred to. This cercaria is redia-produced.

A good deal of difficulty has been experienced in identifying the smaller *Planorbinae* of South Africa, and it is hoped that Pilsbry's work on the Freshwater Shells of the Belgian Congo will throw light on the minute differences between such closely allied species as those that have been identified for me as *Planorbis gibbonsi*, *natalensis*, *crawfordi*, and *anderssoni*. From a disease-prevention point of view it is sufficient to record that one or more of these closely allied species which inhabit the same localities has been found infested with parasites representing the larval stage of some amphistome or other trematode worm; but, in view of the small infestation of these freshwater snails, the matter of securing the adult forms of these cercariae is one of great difficulty.

Other species that I have found in pools infested with cercariae, and which might possibly be mistaken for those I have mentioned, are *Planorbis*

costulatus Krs. from Umgeni, Umbilo, Umbogintwini, and Isipingo, and *Planorbis corniculum* Conn. from Mulder's Drift.

The fact that a species of *Segmentina, S. largillierti*, had been implicated with the spread of Fasciolopsiasis, as mentioned by Dr. Annie Porter in her Presidential Address before the Science Congress at Lourenço Marques in July 1922, made me redirect my attention to species of this genus which I had already examined with negative results in several distinct localities.

I found examples of *Segmentina kanisaensis* in a pool at Merebank which harboured no less than five distinct species of cercariae, but I retained these shells for identification without examining for the possible presence of cercariae. This species of freshwater snail had previously been known only from the Upper Nile.

Segmentina planodiscus, whose shell measured up to 6 mm. in diameter, occurred in most of the pools around Durban where I found cercariae, and examples from the Durban Country Club were infested with a redia-produced styletted cercaria, as well as an eye-spotted cercaria with forked tail, possessing oral sucker and acetabulum and produced in redia, which Dr. E. C. Faust is also describing. This eye-spotted schistosome was seen to swim either backwards or forwards with equal ease. I think this is the first time that a schistosome has been recorded in so small a species of freshwater snail, and indicates that prophylactic measures should be adopted to rid collections of water of all freshwater snails, especially from those smaller stagnant pools where these small *Planorbinae* breed in great numbers.

None of the examples of *Limnaea truncatula* Drap. that I collected in the Transvaal were infested with cercariae and, if this species ever harbours cercariae in this country, it must nevertheless be exceedingly rare as an intermediate host. On the other hand, *Isidora forskali*, which has a dextral shell about the same size as that of *Limnaea truncatula*, is very common indeed, and it must be exceptional for it to occur in any stream without being infested with amphistomes. Judging from the large number of examples that I have found infested with amphistomes, this common little inhabitant of semi-stagnant water must be a very common cause of parasitic disease of animals and birds.

The identification of the various *Ancylidae* which I had collected from various parts of the Transvaal, Cape, and Natal was an impossibility until Mr. Bryant Walker had published (privately) his paper on The Ancylidae of South Africa. I did not think that this family of freshwater snail had been implicated with the spread of parasitic disease in South Africa until I was successful in isolating cercariae, which Dr. E. C. Faust identified as monostomes, in examples of *Burnupia trapezoidea* (Bttg.) from a tributary

of the Caledon River at Schuttes' Draai on the Basutoland border last year. Although I could not see an acetabulum, the outline of these cercariae was identical with that of *Schistosomum haematobium*, and it was somewhat of a surprise to me to find cercariae half a millimetre in total length in shells that were only 6 mm. in length. In July 1923 I had obtained several examples of this shell from a pool at Schuttes' Draai, where allied species were heavily infested with various cercariae, and this fact made me especially desirous of examining these *Ancylidae* for cercariae, as I had the opportunity of doing through the kindness of a friend in October 1923. I have collected *Burnupia caffra* (Krauss), *B. gordonensis* (M. and P.), *B. nana* Walker, *B. capensis natalensis*, *B. mooiensis* Walker, *B. mooiensis dubiosa* Walker, *B. verreauxii* (Bourguignat), *B. stenochorias*, as well as *Ferrissia burnupi* Walker, *F. connollyi* Walker, *F. cawstoni*, *F. lacustris*, *F. fontinalis* Walker, *F. natalensis*, and other unidentified specimens from localities known to harbour cercariae, but up to the present have succeeded in finding cercariae only in *Burnupia trapezoidea* (Bttg.).

ON A SKULL AND PARTIAL SKELETON OF *MESOSUCHUS BROWNI* WATSON.

By S. H. Haughton, B.A., D.Sc.

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(With Plates I and II and one Text-figure.)

The South African Museum has recently received several slabs of sandstone from a quarry on the Commonage, Aliwal North ; these, upon development, yielded parts of three skeletons, two of which belong to the genus *Euparkeria*, while the other consists of a beautiful skull and the associated front half of a skeleton of *Mesosuchus*. For these specimens the Museum is indebted to Mr. A. W. Higgins, who is carrying on the collecting of fossils which he began in association with the late Alfred Brown.

Hitherto the skull of *Mesosuchus* has only been known from the fragmentary type ; and as this new specimen throws a flood of light on the systematic position of the reptile, the following description of it has been drawn up.

Mesosuchus browni was first described by Watson (Rec. Albany Mus., ii, p. 296), and more accurately defined by Broom (Proc. Zool. Soc., 1913, p. 627). Haughton described a second specimen lacking the skull (Trans. Roy. Soc. S. Afr., x, 1921, p. 85), and figured some of the elements, including the tarsus and carpus. The type skull-fragment was figured by Broom (*loc. cit.*, Pl. lxxviii, fig. 12), but somewhat erroneously. Comparison with this new specimen shows that the upper edge of the maxilla in the type—which Broom took for the lower border of the orbit—is a fractured edge ; and the new figures given here will show that the orbit is in reality further from the front of the snout than Broom supposed.

Skull.—The chief measurements of this new skull and lower jaw are as follows :—

Maximum length	91·5 mm.
Maximum width (across quadrato-jugals) . .	63 ,,
Median length (top of skull)	67 ,,
Antorbital length	29 ,,

Length of orbit	23	mm.
Maximum height of skull	33	,,
Interorbital width	16	,,
Length of nasal opening	19	,,
Width of nasal opening	9	,,
Maximum length of lower jaw	95	,,

The main general features are: Nostrils confluent, not separated by a bony internasal septum; no antorbital vacuity; orbits large, looking mainly outwards; upper temporal opening oval in shape; lower opening squarish; lower temporal arcade not complete, both the jugal and squamosal ending in free pointed extremities, and the quadrato-jugal not passing forward from the quadrate.

The *premaxilla* forms the lower half of the narial border, and passes back between the nasal and the maxilla to well behind the plane of the back of the nostril, almost meeting the prefrontal. At the end of the snout it is turned downwards in a Rhynchosaurian manner, and each bone carries two stout blunt acrodont teeth, the anterior one being a sort of miniature tusk. Along the premaxilla-maxillary suture is a fair-sized circular foramen. In the median line at the lower end of the nostril the premaxillae carry a small rounded semi-divided protuberance.

The *nasal* forms the upper half of the narial border, sending forward a projection to lie inside the premaxilla along the outer border of the nostril. The posterior border of the nostril is doubly excavate, the two nasals extending a short distance together into the opening. The nasals are broadest in the middle, where they form nearly the whole of the roof of the snout. Each bone articulates with the frontal, prefrontal, and premaxilla, and for a very short distance only with the maxilla.

The *maxilla* forms a small portion of the antorbital border, but passes back below the jugal to behind the plane of the middle of the orbit. On the right side it carries eleven short blunt acrodont teeth, the dentigerous portion of the bone being defined by a superior longitudinal overhanging eave.

The *lachrymal* has a very small facial portion; it is a small triangular bone wedged between the prefrontal and maxilla along the orbital border.

The *prefrontal* forms a large part of the upper anterior quadrant of the orbital border, and has a long articulation with the maxilla, passing forward almost to the posterior corner of the premaxilla.

The *frontal* is a rectangular bone which only enters for a short distance into the upper border of the orbit. The posterior outer corner touches the upper temporal vacuity.

The *postfrontal* is a triangular bone articulating with the frontal and

postorbital, forming part of the orbital border and part of the border of the upper temporal vacuity.

The tripartite *postorbital* forms more than half of the bar separating the temporal vacuities, its posterior end being pointed and resting outside the squamosal in a triangular groove. Ventrally it meets the jugal on the postorbital bar, passing outside and in front of that bone; and superiorly it lies behind the postfrontal.

The *jugal* has the usual tripartite shape, articulating in front with the maxilla and above with the postorbital. Posteriorly it is free, the lower hinder corner of the lower temporal vacuity being open.

Only a small part of the *parietal* appears on the dorsal surface. Just behind the suture with the frontal the two parietals carry a large elongate hollow which is pierced by a small pineal foramen. The parietal bar is narrow. The bone forms a large wing on the occipital surface, passing outwards and backwards to lie behind the supratemporal.

The *supratemporal* in occipital view is a lenticular bone lying between the parietal and squamosal. It forms the outer end of the posterior border of the upper temporal vacuity and supports in part the lateral wing of the parietal which lies behind it; while the squamosal lies in front of the main mass of the bone. This is the bone called "tabular" by Broom, who (Proc. Zool. Soc., 1922) identifies it as such in *Youngina*, the Ichthyosaurs, the Thalattosauria, and the Lizards. In the Gorgonopsia and other Theromorphs in which a true tabular occurs, the bone is truly a bone of the back of the skull, articulating laterally with the squamosal, but lying *behind* the parietal and in front of the interparietal, being thus homologous with the tabular in *Captorhinus* and the Stereospondyls, but not with the upper of the two temporal elements in *Mesosuchus*. We therefore follow those authors who identify this element as "supratemporal."

The supratemporal does not meet the postorbital.

The *squamosal* forms the hinder half of the bar between the temporal vacuities, lying ventral to part of the postorbital. Medially it articulates with the supratemporal, lying in front of that bone and having a long articulation with it. The lower end of the bone is free. The hinder-lateral border is excavate, the bone being cupped for the reception of the upper end of the quadrate, which is loosely articulated with it. The ventral end of the squamosal meets, and lies slightly upon, the upper end of the quadrato-jugal.

The *quadrate* has a length of 25 mm. and a distal width of 12 mm. Its upper end articulates very loosely with the squamosal, and is broadened. The bone is concave posteriorly, with a thin outer edge and a rounded swollen inner edge. The articular surface is thickened, and is saddle-shaped. Along the outer edge of the bone is a thin splint of *quadrato-jugal*

which touches the squamosal superiorly but does not reach the articular end of the quadrate. Between it and the quadrate is a small quadrate foramen.

The subparietal part of the occipital plate has been shifted from its true position. There is a very small *interparietal*, but I can distinguish no sutures between the median part of the plate and the two lateral paroccipital wings. The upper edges of the latter are concave, so that the plate was pierced on each side by a large, transversely elongate post-temporal vacuity. It is probable that the outer end of each wing met the supratemporal, and it certainly articulated with the squamosal.

The *exoccipital* is a small plate of bone forming the side of the small foramen magnum. Lateral to the exoccipital the paroccipital wing is pierced by a small foramen as in the lizards.

The occipital condyle is single and rounded, formed wholly of the *basioccipital* which sends up a small process to articulate with the base of the paroccipital wing. The ventral surface of the basioccipital consists of a short broad plate with posterior lateral wings which form the hinder borders of the fenestrae ovales. In front the bone articulates with the basisphenoid in a slightly digitating suture.

The ventral surface of the *basisphenoid* is a domed plate which has a posterior lateral process on each side to form the anterior wall of the fenestra ovalis—which is partly occupied by one end of the *stapes*. Just in front of the fenestra ovalis the basisphenoid is pierced by a small oval carotid foramen which appears to be confluent by means of a short canal with the fenestra ovalis. The anterior border of the bone is not fully displayed, but it presumably articulates with short blunt processes of the pterygoids.

The *pterygoid* is separated from its neighbour by a well-defined suture, but the opening between them is not as broad as in *Howesia*. The bone is an elongated twisted bone—the anterior and middle parts roughly horizontal, the posterior processes (the basisphenoidal and quadrate processes) lying in a more vertical plane. Anteriorly the pterygoid has two divergent ridges, each of which carries rows of short, blunt, rounded teeth. The basisphenoidal process is short and rounded ; the quadrate process is longer, narrow, and slightly curved outwards posteriorly.

The whole of the lateral portion of the centre plate of the palate is formed by the *ectopterygoid*, which articulates with the pterygoid in a long straight suture.

The anterior part of the palate is not displayed, owing to the presence of the lower jaw ; but, according to Watson, the vomer (in the type) is apparently narrow, with a series of small pointed teeth, and is articulated with the anterior end of the pterygoid.

Lower Jaw.—This is best displayed in the type specimen, but this new specimen shows further features.

A large *splenial* lies inside the dentary and meets its neighbour at the lower end of the symphysis. The *surangular* is much larger than the dentary, with a length of 62 mm., and extends from below the front point of the jugal almost to the extreme end of the postarticular projection, where it lies outside and below the articular. It lies outside the posterior part of the angular.

The postarticular process is 12 mm. long, strong and thick, with a hollowed pit on the upper surface and a swollen rim at its end. A *prearticular* lies on the inner side of the articular in front of the condyle.

Vertebral Column and Ribs.—Of the atlas and pro-atlas nothing can be seen save the ventral surface of the odontoid, which is crushed against the quadrate process of the pterygoid, and a small piece of bone lying against the left exoccipital.

The body of the axis is not completely exposed. It is laterally compressed and has a strong median ventral keel. Posteriorly it is 7 mm. wide ; the greatest height of the bone is 25 mm. The neural spine is high and long, its dorsal surface sloping forwards and downwards and having a length of 20 mm. The width across the postzygapophyses is 9 mm. ; their under surface is horizontal.

The 3rd cervical is 12 mm. long, its ventral border concave with the posterior end lower than the anterior. The centrum is strongly compressed in the middle, and has a ventral median keel and weak lateral longitudinal ridges. The articular faces are slightly concave, with a broadly rounded rim. There is a small tubercle on the side of the body just behind its anterior end. In the 4th cervical this diapophysis is much stronger, slightly higher on the body, and very near the anterior surface. Here the centrum is 12 mm. long, and the height to the top of the prezygapophysis 14 mm.

The 6th cervical is 13 mm. long and 29 mm. high. The posterior face is 11 mm. high. The neural spine is longer above than below, its anterior edge sloping forwards and upwards. Throughout the neck the neural canal is large. The centra are only slightly amphicoelous.

Dorsal vertebrae are only displayed in ventral view. The centra are 11·5 mm. long, strongly constricted, with a median keel. The ends are about 11 mm. wide. Small intercentra are present in the anterior dorsal region.

The cervical ribs—some of which had to be destroyed in the development of the basicranium—were short, slender, and double-headed. The dorsal ribs are long and single-headed. There was a ventral armour of small abdominal ribs.

Shoulder-girdle.—This is preserved and seen in ventral view. The *scapula* is large and broad. The length of the posterior border is 28 mm., while the minimum width of the shaft is 16·5 mm. The whole plate is thus broad in comparison with its length, and slopes considerably backwards.

The front edge is concave, and the anterior part is thinner than the remainder of the bone. There is no distinct acromion process, but 10 mm. below the upper anterior corner the bone is suddenly bevelled slightly and there is a small break in the regular curvature of the front border. It is possible that the upper end of the clavicle rested against the slightly grooved portion of the scapular face thus formed. Above the glenoid cavity the bone is thickened, and there is a supraglenoid ridge.

The single *coracoidal* element is flat and plate-like, meeting its neighbour in a long articulation. The greatest length of the bone is 38 mm. There is a short postglenoid process. The glenoid cavity is small. The coracoidal foramen lies 6 mm. in advance of the glenoid cavity and slightly medial to it.

The *clavicle* was about 37 mm. long, spatulate proximally and rod-like distally.

What must be the anterior end of the *interclavicle* is preserved, and now lies partly dorsal to the coracoids. It is broad anteriorly, with two vertical faces for the reception of the spatulate ends of the clavicles. The ventral surface of this rhomboidal end is recessed, recalling the condition in the interclavicle of *Broomia*, and tending to show that the interclavicle largely lay above the coracoids as in that genus and in the Plesiosaurs.

Posterior to the coracoids, and lying in the angle between them, is a rounded impression which may represent the end of an elongate interclavicle, or a small sternum.*

Fore-limb.—The left *humerus*, of which part of the proximal half is missing, was 44·5 mm. long. The proximal width was 24 mm., the distal width 22 mm., and the minimum width of the shaft—which is nearly circular in cross-section, 6 mm. The upper and lower ends make with each other an angle of about 45°. The proximal articular surface is long and narrow, slightly bowed, and is marked off from the deltopectoral crest, which is 16 mm. long, by a distinct angle. The bicipital fossa is slightly concave. At the distal end the entocondylar side is slightly more elongate than the radial. Dorsally, two rounded ridges run to the condyles, and between them the bone is shallowly excavate. Ventrally, the excavation above the radial articular surface is more hollowed out. Lateral to this radial surface there is a shallow longitudinal channel, the distal end of which forms a notch in the bone. This notch is the end of an entepicondylar groove which passes upwards to a point on the lateral face about 5 mm. from the distal end. There is no ectepicondylar foramen.

The *radius* is a slender, slightly bowed bone, 36 mm. long, and swollen at each end. The *ulna* is stouter, apparently somewhat shorter than the radius.

Systematic.—The absence of a preorbital vacuity reduces the number

* See Addendum.

of Diapsidan reptiles with which *Mesosuchus* can be usefully compared, and we shall consider here only its relations with *Youngina*, the Sphenodontia, the Rhynchosauria, *Paliguana* and the Lizards, *Howesia*, and the Thalattosauria.

Youngina is a Diapsid reptile without antorbital vacuity, possessing a supratemporal bone (" tabular " of Broom), with the frontal forming only a small portion of the orbital border, and with the postfrontal touching the parietal on the border of the upper temporal vacuity. But it differs from *Mesosuchus* in a number of points, in all of which the latter genus (which is from the *Cynognathus* zone) shows an advance on the earlier *Cistecephalus* zone form *Youngina*. The chief points of difference are that in *Mesosuchus* (*a*) the nostrils are single and terminal, (*b*) the dentition is acrodont, (*c*) the nasal is almost excluded from articulation with the maxilla, (*d*) the supratemporal does not meet the postorbital, (*e*) the interparietal is very small, (*f*) the lower arcade is incomplete, (*g*) the parietal ridge is narrow.

The Sphenodontia, typified by the living *Sphenodon*, have the lower temporal arcade complete, separate nostrils, and no supratemporal; and they differ from *Mesosuchus* in the detailed arrangement of the bones of the face, while the frontal forms most of the supraorbital border. The pterygoid and vomer carry no teeth in the adult. As in *Mesosuchus*, intercentra are present, the cervical ribs are double-headed and the dorsal ribs single-headed, but the shoulder-girdle of *Sphenodon* is more reduced. The best-known Triassic member of the family is *Brachyrhinodon* from the Trias of Elgin (Huene, Neues Jahrbüch f. Min., 1910, ii, p. 29), the distal end of the humerus of which shows some similarities to that of *Mesosuchus*.

In the possession of a single narial opening, *Mesosuchus* agrees with the Rhynchosauria (*Rhynchosaurus*, *Hyperodapedon*, *Stenometopon*), but it differs from them in the structure of the lower temporal opening. The Rhynchosauria lack a supratemporal and there is no pineal foramen. A quadrate foramen is certainly absent in *Hyperodapedon* and doubtfully so in *Rhynchosaurus*. The premaxilla is produced into a beak and carries no true teeth. Points of agreement, beside that of the single nostril, between *Mesosuchus* and this family are : The nasal is almost excluded from contact with the maxilla (in *Rhynchosaurus* the two bones are entirely separated) ; the frontal scarcely enters the orbital border ; pterygoidal teeth are present ; the interpterygoid vacuity is long and narrow.

Comparison with the Lacertilia shows some interesting features. The earliest supposed lizard is *Paliguana whitei* from the Triassic of South Africa, which has an incomplete lower arcade, formed by a short backwardly projecting process of the jugal. There are few other points of similarity with *Mesosuchus*, and the two forms are obviously very different.

In recent lizards there is only one temporal vacuity surrounded by bone,

but forming the hinder border of this are two temporal bones. Watson (1914) held that the lizards have only a single temporal fossa, and that the two temporal bones are squamosal (inner) and quadrato-jugal (outer). Examination of a skull of *Varanus* shows the temporal bones to correspond exactly with those of *Mesosuchus*. The bone called by Watson "quadrato-jugal" forms part of the outer bar of the (upper) temporal vacuity and articulates anteriorly in a long suture with the single postorbital-postfrontal element (*not* jugal), forming posteriorly a cap for the streptostylic quadrate and articulating with the outer end of the paroccipital; the inner temporal bone lies in front of the parietal and behind the outer temporal element, and articulates ventrally with part of the paroccipital. These conditions are exactly as in *Mesosuchus*. But in the latter there is an undoubted quadrato-jugal lying lateral to the quadrate, and the two temporal elements are squamosal (outer) and supratemporal (inner). Hence we must conclude that in the lizard's skull the two bones are likewise squamosal and supratemporal, and that the temporal vacuity present is the upper—the lower vacuity having, in the course of evolution, lost its lower border of jugal and quadrato-jugal by the reduction of these elements.

In this connection it is interesting to note that skulls of two such different Lacertilian genera as *Zonurus* and *Agama* show short backwardly directed processes of the jugal forming remnants of a reduced lower arcade; whilst the skull of *Agama* shows the quadrate pierced by a large quadrate foramen covered with cartilage, the outer border of which is a curved rod of bone which—although not visibly separated by sutures from the main mass of the quadrate—may be a quadrato-jugal.

Mesosuchus shows differences from the Lacertilian skull in the nostril, the position of the pineal foramen, the shape of the parietals and many other features, but it is of interest in showing one of the stages by which the loss of the lower temporal arcade has been accomplished.

Howesia (from the *Cynognathus* zone) is a not very well-known form which shows certain resemblances to *Mesosuchus*. The South African Museum possesses the described material. Specimen B (S. Afr. Mus. Cat. No. 5885), described by Broom, shows what I think is an undoubted supratemporal occupying a similar position to that of the "tabular" figured by Broom in *Youngina* and *Thalattosaurus*. I give a new figure of the specimen showing the bones as they actually occur. The quadrate of *Howesia*, too, is very like that of *Mesosuchus*; and its outer border as preserved argues the presence in the complete skull of a quadrato-jugal and a quadrate foramen. In specimen A (Cat. No. 5884) the jugal seems to have a free pointed posterior end as in *Mesosuchus*. Nothing is known of the snout in *Howesia*. I have elsewhere pointed out the similarities in the pelvic girdles and limb-bones of the two forms; and they have somewhat similar scapulae and coracoids.

The main difference is in the dentition—the excessive production of teeth in *Howesia* being a specialisation. As far as the known portions of the palate are concerned, the two forms are not very far removed from each other.

The Thalattosauria are Triassic forms from California which, although adapted for an aquatic life, show some points of resemblance to *Mesosuchus*. They are two-arched reptiles without a preorbital vacuity but with widely separated nostrils. Apparently the quadrato-jugal is not present; and it is doubtful whether the jugal reaches back to the quadrate to close the lower temporal opening. A large supratemporal is present. There is a pineal foramen situated in front of the parietal bar as in the lizards; and the frontal forms only a small portion of the orbital border.

From this short survey it can be seen that *Mesosuchus* does not readily fall into any of the known families of Diapsid reptiles, and for it a new family is therefore proposed, which may be called the *Mesosuchidae* and placed in the new sub-order *Mesosuchidia* of the Diaptosauria. This can well have been derived from the Eosuchia (*Youngina*). It is more primitive than the Rhynchosauria in some features, but more advanced in the reduction of the lower temporal arcade. In the latter feature it foreshadows the Lacertilia; but the structure of the nostril removes it from the direct line of evolution of that sub-order. Nor is it closely connected with the Thalattosauria in spite of the points of similarity. *Howesia* may be a member of the *Mesosuchidia*, but we must find further evidence as to the structure of the front part of the skull.

EXPLANATION OF PLATES.

Plate I.

Fig.		
1.	*Mesosuchus browni.*	Side view of skull and lower jaw (S.A.M., No. 6536) slightly reduced.
2.	,,	Top view of skull (Cat. No. 6536). Slightly reduced.
3.	,,	Restoration of occipital view. Enlarged.
4.	,,	Palate of specimen 6536 as preserved.
5.	,,	Outline of axis—specimen 6536.
6.	,,	Sixth cervical vertebrae, slightly enlarged.
7.	,,	Ventral view of shoulder-girdle—reduced.
8.	,,	Ventro-lateral view of left shoulder—reduced.
9.	*Howesia browni.*	Skull-remains in specimen S.A.M., No. 5885.
10.	,,	Quadrate—S.A.M., No. 5885.

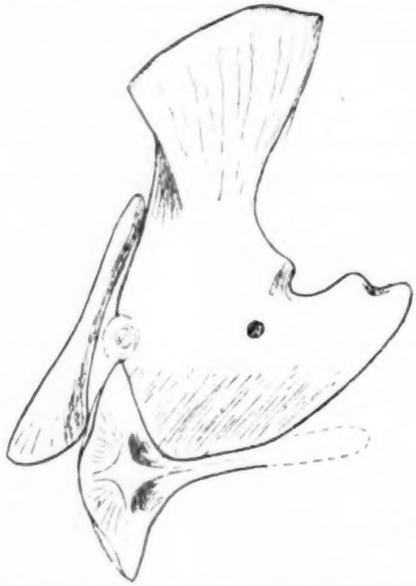
Plate II.

1.	*Mesosuchus browni.*	Antero-dorsal view of snout in skull No. 6536 to show true shape of nares. Slightly enlarged.
2.	,,	Articular region in skull 6536.
3.	,,	Latero-ventral view of right ramus of lower jaw — S.A.M., No. 6536.

Fig.		
4.	*Mesosuchus browni.*	Left humerus, showing full ventral view of proximal end. Slightly enlarged.
5.	,,	Left humerus, showing full ventral view of distal end. Slightly enlarged.
6.	,,	Left humerus. Dorsal view of distal end. Slightly enlarged.
7.	*Varanus.*	Dorsal view of back half of skull of living *Varanus.*

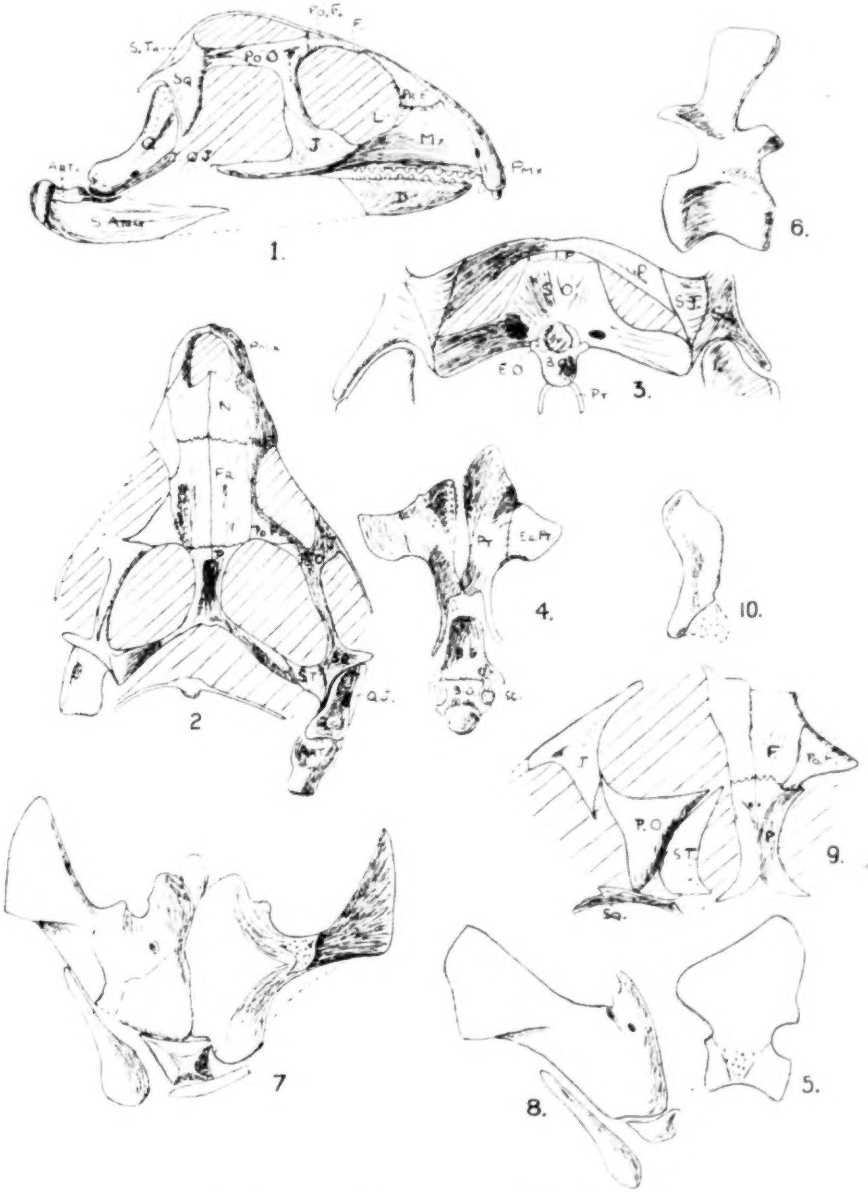
ADDENDUM.

Since the above paper was sent to press, I have further developed the interclavicle by chipping away the stone carrying part of the impression of the right coracoid. It can now be seen that the interclavicle is an elongate bone with a broadly expanded rhomboidal head, twisted slightly



TEXT-FIG. 1.—*Mesosuchus browni*, Broom.—Shoulder-girdle as seen from left side, looking slightly upwards.

from its proper position and presumably pushed in a dorsal direction by the squeezing together of the coracoids. The rounded impression which I took to be possibly "the end of an elongate interclavicle, or a small sternum" is really the posterior process of the left coracoid. I give a figure of part of the shoulder-girdle as now exposed.



1–8. *Mesosuchus browni* Watson. 9–10. *Howesia browni* Broom.

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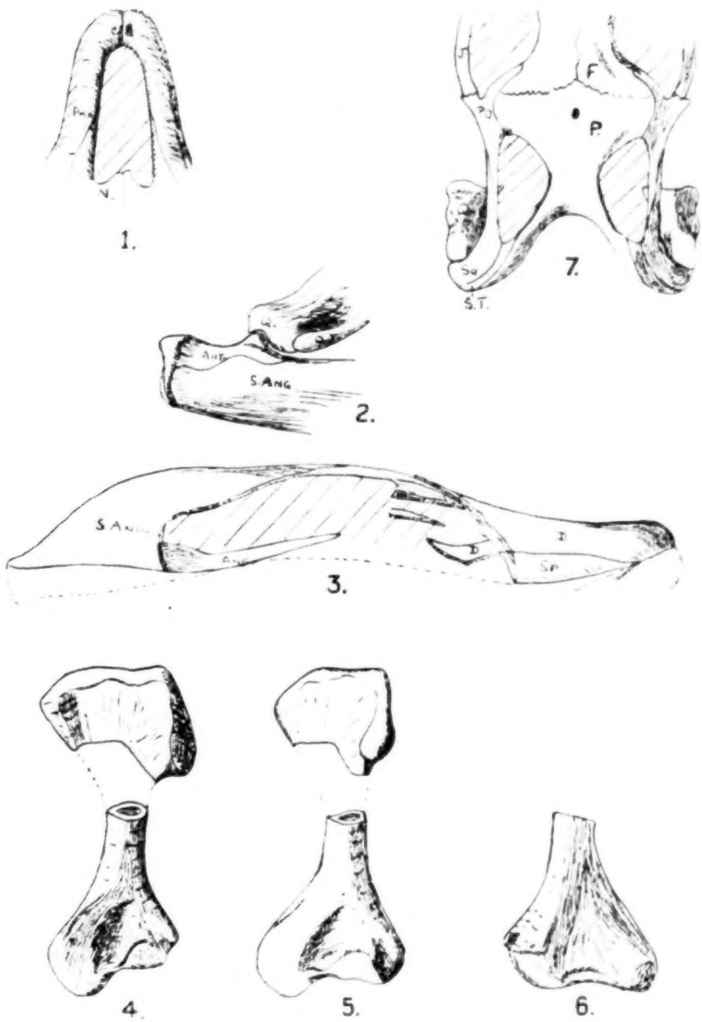

1–6. *Mesosuchus browni* Watson. 7. *Varanus* sp.

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THE DIGESTIVE CANAL OF ISOPOD CRUSTACEANS.

By K. H. Barnard, M.A., F.L.S., F.R.S.S.Afr.

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(With Plate III and one Text-figure.)

In the course of an investigation into the anatomy of *Phreatoicus capensis* Brnrd., I have been led to examine several other types of Isopod for the sake of comparison. The present paper embodies some of the results of a comparison of the digestive canals, and more particularly of the stomachs; and while not claiming to be by any means exhaustive, may serve nevertheless to direct attention to the interesting problems still awaiting study in this somewhat neglected (anatomically) group.

In 1909 Calman had perforce to write, regarding the particular organ here studied, that "the number of types in which its structure has been studied is, however, too small to admit of profitable comparisons between them" (p. 208). Since then apparently no other types have been studied with the exception of *Bathynomus*. Lloyd's account of this form, though dated 1908, was too late for mention by Calman. Smith (1909) has examined some of the Australian Phreatoicids, but, as will be shown elsewhere, his remarks are open to very grave doubts and criticism. Even the suctorial type represented by *Aega* appears not to have been studied in detail with a view to comparison with other types.

In the following account the several types are arranged not according to any plan of systematic classification, but on a physiological basis according to their mode of feeding and the character of the ingested food.

Ligia, of which Hewitt has given a clear and concise account, is taken as a basic type, as it appears to possess all the typical structures of the Isopod stomach. The modifications found in representatives of other families can all be compared with this basic type and shown to be correlated with differences in habits and diet.

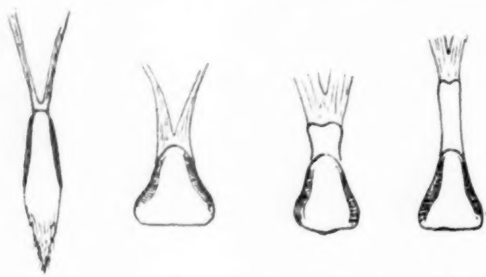
Although I deal here mainly with the stomach (gizzard or foregut), special modifications of the pharynx (oesophagus) are noted, as also the number of hepato-pancreatic glands; but the intestine (mid- and hindgut) is only incidentally mentioned, as this feature is often difficult to make out clearly in these small animals without specially preserved material.

It was found that the structures of the stomach could easily be observed by treating it with caustic potash and then staining, very lightly, with haematoxylin. In the case of *Phreatoicus*, serial sections have also been examined. A detailed account of this form will be given in another paper.

One structure, which provides the key to the explanation of the physiological and morphological modifications of the stomach, appears to have been overlooked by previous writers.

A brief account of the structure of the stomach in *Ligia* may first be given. It is the type of the herbivorous or, more correctly, omnivorous Isopods.

The various invaginations of the wall of the stomach to form triturating pads or valvular lamellae may be grouped into an anterior (cardiac) and a



a *b* *c* *d*

TEXT-FIG. 1.—Median ventral tooth with tab and bifurcating muscle. *a*, *Phreatoicus* ; *b*, *Cirolana* ; *c*, *Meinertia* ; *d*, *Nerocila*.

posterior (pyloric) series. The anterior series comprises: (1) the large lateral cardiac triturating teeth or pads (*l.c.t.*), which include the lateral cardiac teeth and also the antero-lateral teeth of Hewitt, and between which is a medio-dorsal (*m.d.t.*) tooth, all three being covered with setae ; (2) two ventral cardiac ridges (*v.c.t.*), more or less transverse, which are minutely and very regularly striate and bear on their posterior edges a close-set, comb-like row of setae.

The posterior series comprises: (1) a horizontal dorsal lamina (*d.l.*) projecting into the lumen of the intestine ; (2) a medio-ventral, longitudinal trenchant tooth (*m.v.t.*) rising from the bottom of a groove bordered on each side by a submedian ridge (*sm.v.r.*), which is usually setose: the posterior half of the median tooth projects freely and ends in an acute setose point ; (3) on either side of, and commencing at the end of, the submedian ridges is a horizontal lamella (*v.l.*) projecting back into the lumen of the intestine.

Connecting the cardiac and pyloric series is a lateral setose ridge (*l.r.*)

running obliquely from the top of the lateral cardiac tooth down to the commencement of the ventral lamella and then curving round to run transversely to the end of the submedian ventral ridge.

The common duct of the hepato-pancreatic glands (*hep.*) opens at the ends of the submedian ventral ridges, where the median ventral tooth starts to project freely.

Projecting from the external (ventral) surface of the median ventral tooth at its anterior end is a little chitinous tab or papilla (*p.*) (text-fig. 1), to which is attached a muscle. This muscle runs forwards beneath the pharynx, bifurcates, and is attached to the ventral sternite behind the lower lip. This feature has apparently been overlooked, but, as will be shown, is of considerable importance from the comparative and physiological points of view. By means of this muscle the median ventral tooth is put into action.

Ligia glabrata and *dilatata*. (Figs. 1 and 2.)

Stomach oval or pear-shaped, broadest anteriorly. As described by Hewitt for *oceanica*, all the parts normally developed. The dorsal lamina is emarginate on its posterior border.

A certain slight specific difference is noticeable in the length of the ventral lamellae. In the two species above mentioned, and in *exotica*, they are somewhat bluntly pointed and not very long. In an undescribed species (Barnard MSS.) they are considerably longer but still apically blunt. In *oceanica* they are long and taper to acute points.

The anterior ventral ribbed teeth are crescentic, and the anterior lateral triturators are covered with long, hair-like setae. The lateral oblique ridges are setose.

In *Ligia glabrata* and *dilatata* a specimen 22 mm. long has a stomach measuring $3{\cdot}25 \times 2{\cdot}5$ mm.

Family Tylidae.

Tylos granulatus. (Fig. 3.)

Herbivorous.

A specimen 35 mm. long has the stomach measuring 5×3–4 mm. (3 mm. in the anterior, 4 mm. in the posterior part).

Subtriangular in shape, widening posteriorly. Normally developed. The anterior lateral triturators are very thickly covered with long, hair-like setae, as is also the medio-dorsal tooth. Ventral ribbed teeth forming a right angle on either side, first longitudinal and then transverse. Lateral oblique ridges setose. Ventral lamellae short, ovate. Dorsal lamina broad and long, strongly excavate between two lateral curved horn-like processes which extend into the intestine.

The greater development of the dorsal lamina as opposed to the ventral lamellae is exceptional and noteworthy.

Family Scyphacidae.

Deto echinata. (Fig. 4.)

Herbivorous.

A specimen 26 mm. long has a stomach measuring $2{\cdot}5 \times 1{\cdot}3$ mm.

Normally developed, except that the anterior medio-dorsal tooth is absent. The anterior ventral ribbed teeth are nearly straight, and diverge posteriorly. The anterior lateral triturators are covered with short, hair-like setae. Dorsal lamina short, posteriorly broadly emarginate. Ventral lamellae extending a long way into intestines, rather narrow, and tapering to fine points.

Family Idoteidae.

Paridotea reticulata. (Fig. 5.)

Herbivorous.

Stomach $12 \times 2{\cdot}5$ mm. in a specimen 63 mm. long.

All parts normally developed. Anterior lateral triturators closely set, with hair-like setae. Oblique lateral ridges setose. Dorsal lamina and ventral lamellae very long, stretching far into intestine, the former apically bifid, the points blunt, the latter tapering rather suddenly near the end to a (somewhat twisted) point.

Family Astacillidae.

Antarcturus kladophoros. (Fig. 6.)

Herbivorous.

♂ specimen (described by Barnard, 1914), 18 mm. long, with stomach $2 \times 0{\cdot}75$ mm. Of the same elongate narrow type as in *Paridotea*, the dorsal lamina bifid with the points acute, the ventral lamellae tapering gradually to long, fine points.

Family Sphaeromidae.

Cymodoce valida and *Cilicaea latreillei.*

Omnivorous.

Stomach almost as long as broad, measuring $5 \times 4{\cdot}5$ mm. in specimens 22 mm. long.

All parts normally developed. The anterior lateral triturators are covered with setae, among which are several large and strong spines.

Anterior ventral striated ridge forming a quadrant, partly longitudinal and partly transverse. Oblique lateral ridges joining the ends of the medio-lateral ventral teeth, setose. Ventral lamellae quadrangular. Dorsal lamina transversely quadrangular. In addition there is a medio-ventral tooth between the anterior striated ridges and on the dorsal surface a narrow V-shaped ridge, bearing setae round its edges, and apparently movable by means of a small peg on the outer side of the stomach wall.

Sphaeramene polytylotos.—In this species the last-mentioned feature is absent, and the spines on the anterior lateral triturators are serrulate and some of them trifid or even multifid (fig. 7).

Family Serolidae.

Beddard (1884) has given two drawings of the stomachs of *Serolis schythei* and *bromleyana* (pl. 10, figs. 4 and 9), unaccompanied by any description. So far as one can make out the figures the correlation of Beddard's terms with those used here is as follows: "RP" and "LP" are the ventral cardiac teeth, "1" the lateral cardiac tooth, "2" the submedian ventral ridge, and "T" (fig. 9) the median ventral tooth. The stomach appears to be normally developed, but should be re-examined. I have no specimens.

Family Asellidae.

Asellus aquaticus. (Fig. 8.)

Herbivorous; ? also carnivorous.

Stomach oblong in shape. Normally developed, except that the medio-dorsal anterior tooth is apparently absent.

Anterior lateral triturators with two rows of spines as well as setae. Ventral ribbed teeth longitudinal, parallel or nearly so. Lateral oblique ridges setose. Ventral lamellae quadrangular, apically truncate. Dorsal lamina extending further, bifid, the apices blunt but serrate.

Family Phreatoicidae.

Phreatoicus capensis and *kirki.* (Fig. 9.)

Mud-swallower.

Stomach measuring $1{\cdot}5 \times 1{\cdot}25$ in an animal 14 mm. long.

Normally developed. Antero-lateral triturators setose and spinulose, some of the spinules bi- or trifid. Medio-dorsal tooth setose. A low medio-ventral ridge between the two ventral striated ridges, which are parallel. Medio-ventral posterior tooth between strong setose ventro-lateral ridges. Lateral oblique ridges setose. Ventral lamellae not very long, apically

rounded and setose. Dorsal lamina reduced to a low, transverse, sparsely setose ridge. Inner surface of dorsal and ventral walls setulose.

Three pairs of hepato-pancreatic glands, with anterior forward extension as in *Ligia* (Hewitt, p. 17).

Family Munnopsidae.

Munnopsurus mimus. (Fig. 10.)

Mud-swallower.

Stomach measuring 2×1 mm. in a specimen 14 mm. long. Oblong in shape. Its structure shows evident reduction and simplification.

The anterior lateral triturators are represented by two thin vertical plates projecting at right angles to the wall of the stomach and bearing 12–15 simple spines. No medio-dorsal tooth. Ventral anterior teeth forming two semicircular ridges with their concave sides opposed to one another, the margins fringed with setae. Medio-ventral posterior tooth bearing a simple strong apical spine or narrow projection. Ventral lamellae elongate, scarcely tapering, apically blunt. Dorsal lamina obsolete except at the sides, where there is a subtriangular invagination.

Family Anthuridae.

Cyathura estuarius. (Fig. 17.)

Pharynx exceedingly long, the stomach displaced back in the 2nd peraeon segment. Lining of pharynx medio-ventrally setose. Pharynx passing gradually into stomach without constriction or marked widening. Stomach narrow and elongate. Antero-lateral triturators and medio-dorsal tooth entirely absent.

Ventral ridges subparallel, diverging posteriorly, setose, enclosing an (anterior) medio-ventral, lanceolate, setose tooth projecting freely at hinder end. After this comes the true (posterior) medio-ventral tooth, which is very narrow anteriorly, widens posteriorly, and ends in a freely projecting setose triangular point. Submedian ventral ridges very well marked, densely setose. Ventral lamellae short, oval, setose, projecting a short way into intestine. No dorsal lamina or invaginations. I was unable to determine the presence of a tab, with its bifurcate muscle, on the lower anterior end of the medio-ventral tooth.

While the pyloric region of the stomach is quite normally constructed, the cardiac region presents a structure only met with (in the types examined by me) elsewhere in *Munnopsurus*: namely, the (anterior) medio-ventral tooth and its flanking ridges, which, though not so strongly curved as in *Munnopsurus*, are evidently similar. I am unable to suggest any physio-

logical reason for the development of this essentially similar structure in two such widely separated forms as a Munnopsid and an Anthurid. Further comparative studies may reveal a clue. It must be remembered that we do not know what is the food of these Anthurids, of which the one here examined belongs to the section with normally developed mouth-parts.

Unfortunately I have no material of those species (*e.g. Paranthura*), with the mouth-parts modified for piercing, which is well enough preserved to afford a comparison. It seems reasonable to suppose from the structure of the mouth-parts that the mode of feeding is different, and that this will have had some correlated effect on the structure of the stomach.

Family Cirolanidae.

Cirolana venusticauda, hirtipes, undulata. (Figs. 11 and 12.)

Suctorial.

Pharynx very short and wide, but laterally compressed, a groove (B) in dorsal wall posteriorly. Stomach also short, not longer than pharynx, dorsally convex, laterally somewhat compressed, the lateral margins projecting forwards over the junction with pharynx, in which crevices (A) strong muscles are inserted for the constriction of the posterior part of the pharynx and anterior part of stomach. The inner opposing faces of these antero-lateral margins bear a minutely ciliate vertical fringe (*f.*). Antero-lateral triturators (*l.c.t.*) not strong, but forming a prominent projecting knob. Ventral striated plates transverse (*v.c.t.*). Ventral median tooth broadly triangular. No dorsal lamina or invaginations. A parabolic ridge (*r.*) runs on the outer wall from the middle of the antero-lateral margin obliquely upwards to the dorsal surface. Ventral lamellae contiguous basally across the ventral wall behind and above the broad posterior end of the ventral median tooth, and projecting vertically upwards as a bilobed flap. No oblique ridges.

Midgut joining stomach without overlap. No distinction between mid- and hindgut.

Three pairs of hepato-pancreatic glands.

Family Bathynomidae.

Parabathynomus natalensis g. et sp. n., Brnrd. MSS.

Suctorial.

The description of the stomach of the species of *Cirolana* just given applies equally to this form, except in one unimportant particular: the ventral lamellae are more elongate vertically.

The midgut scarcely forms an appreciable pouch or hood over the hinder

part of the stomach. The midgut is, however, differentiated from the hindgut, and its posterior end projects into the lumen of the latter as in *Bathynomus*, though not to such an extent.

The hepato-pancreatic glands were too poorly preserved to determine their number or structure.

It is curious that this form, so obviously related to *Bathynomus*, should possess such a markedly dissimilar stomach. It would perhaps be more correct to say that the remarkable point is the development of the Cymothoid paired dorsal invaginations in *Bathynomus*, seeing that both forms are so clearly Cirolanid in origin.

For the sake of comparison I give a brief description of the stomach of *Bathynomus* so far as I am able to understand and correlate Lloyd's terms (1908) with those employed here.

Bathynomus giganteus.

Pharynx short and rather broad. Anterior lateral triturators (" ant. ampullae ") present, but apparently entirely devoid of either setae or spines. Anterior ventral striated ridges transverse. A " posterior ampulla " on each side, which apparently is homologous with the oblique ridge in *Ligia*. A pair of " medio "-ventral posterior teeth with trenchant edges (" lower valvular processes ") and two other medio-lateral ridges anterior to these. These appear to be the triangular ventro-median tooth and its two flanking ridges. No dorsal lamina, but two submedian invaginations projecting as finger-like processes (" upper valvular processes ").

The pharynx and antero-ventral ridges are Cirolanid, while the paired dorsal invaginations are Cymothoid.

The tab on the medio-ventral tooth and its tendinous attachments appear to have been entirely overlooked by Lloyd.

Family Aegidae.

Aega semicarinata.

Suctorial.

Pharynx long and slender. Stomach quadrangular, $1{\cdot}25 \times 1{\cdot}25$ mm. in a specimen 53 mm. long, extending into 1st peraeon segment. Anterior dorsal and lateral triturating pads obsolete. Ventral ribbed plates transverse. Ventral median tooth broadly triangular. Framework of stomach strong, antero-lateral angles prominent.

Midgut occupying the 2nd peraeon segment and opening by a narrow vertical slit into hindgut, which is enormously dilated and extends to the end of 7th peraeon segment, whence it narrows again.

Three pairs of hepato-pancreatic glands; short, not extending beyond end of 2nd peraeon segment.

Family Cymothoidae.

Anilocra capensis. (Figs. 13 and 14.)

Suctorial.

A specimen 50 mm. long had the stomach scarcely 3 mm. in length. It was situated in the 1st peraeon segment, the pharynx being unusually long. The latter is laterally compressible, a groove running along the ventral and another along the dorsal surface. The stomach is depressible dorso-ventrally, so that the chitinous junction between the pharynx and stomach is folded somewhat in the manner of the angle of a camera bellows. The stomach is roughly quadrangular, as broad as long, the ventral wall more strongly chitinised than usual.

The anterior dorso-lateral triturating pad here takes the form of a transverse, rather strongly chitinised rib, which is covered with a close thick pilosity on its inner surface and which can be closed down upon the ventral striated plates. These latter are mere ridges, set transversely, but bearing a row of strong contiguous setae projecting backwards.

The ventral median tooth is strong, triangular, its lateral margins minutely striate, the tab at its anterior end strong, narrow, and elongate. Ventral lateral teeth bordering the median tooth with a fine close pilosity, their posterior borders rounded but scarcely projecting beyond posterior margin of median tooth. Ventral lamellae forming a bilobed flap projecting upwards into the lumen of stomach. No dorsal lamina. On the dorsal wall are two parallel finger-like invaginations (*d.i.*) extending back to the limit of the stomach (probably homologous with the upper valvular processes in *Bathynomus*).

The intestine joins the stomach without overlap, and there is no visible differentiation between midgut and hindgut.

Three pairs of elongate hepato-pancreatic glands extending back to 6th peraeon segment and opening by very large ducts. The glands appear externally to be composed of a number of small oval or oblong "cells."

Meinertia imbricata. (Fig. 15.)

Essentially similar to that of *Anilocra*. In a specimen 55 mm. long the stomach was 2·5 mm. in both length and width. The ventral surface is even more strongly chitinised than in *Anilocra*. The tab (text-fig. 1, *c*) of the ventral median tooth is short and broad. The dorsal invaginations project slightly into the intestine.

Nerocila rhabdota. (Fig. 16.)

Essentially similar to that of *Anilocra*. Stomach in the 1st peraeon segment, pharynx long.

No distinction between mid- and hindgut. Hepato-pancreatic glands: three pairs extending to 5th or 6th peraeon segment.

From the foregoing examples it will be seen that the Isopod stomach, though built on the same general plan throughout the group, shows family, generic, and in some cases even specific, differences.

In the deep-water *Munnopsurus* considerable simplification has occurred, and a peculiar structure is developed which is met with again in *Cyathura*.

In both *Phreatoicus* and *Munnopsurus* a reduction of the dorsal lamina occurs which apparently is correlated with the habit of mud-swallowing.

The greatest departure from the normal type, however, occurs in those families which have developed a suctorial method of obtaining nourishment.

Firstly, the lateral triturating pads and the ventral cardiac ridges are to a large extent degenerate. The stomach has ceased to be a mill and has become a pump. In fact it is exactly comparable with a piston and cylinder. For this purpose there must be valves at the points of ingress and egress. Thus the aperture at the junction of the pharynx and stomach can be completely closed by means of muscles and interacting folds in the pharynx. The posterior opening between the stomach and intestine is closed either by the more or less fused ventral lamellae (*Cirolana*) or by a pair of large dorsal invaginations (*Cymothoidae*). The (fused) ventral lamellae do not entirely disappear in the Cymothoid type, but compared with their size in *Cirolana* they are much reduced.

The piston which works in this cylinder is formed by the medio-ventral tooth (*m.v.t.*). The elongate trenchant tooth of the normal type (text-fig. 1, *a*) has become shortened into a broad triangular and strongly chitinised boss (text-fig. 1, *b*–*d*). The action of the bifurcate muscle attached to the tab at its lower anterior end causes the piston-like movement of this boss. It seems strange that even in such a large animal as *Bathynomus* this important and essential structure should have been overlooked.

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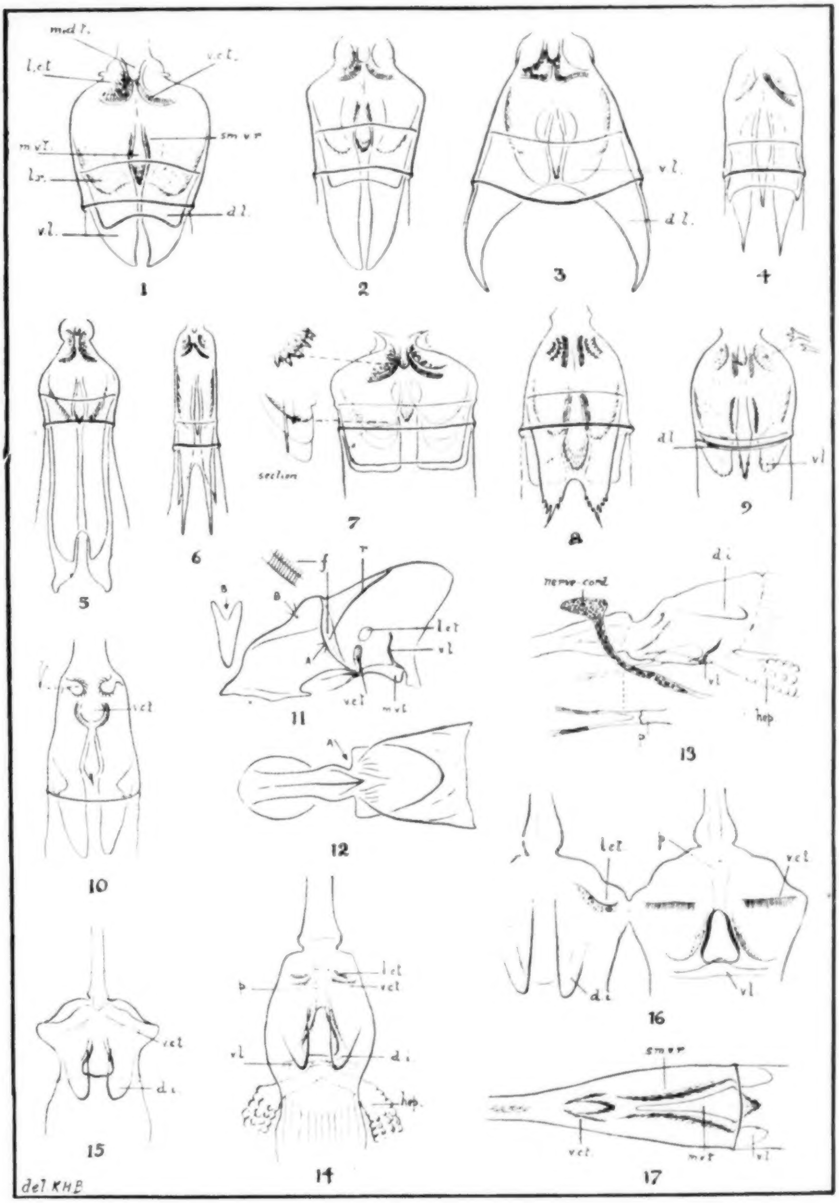

STOMACHS OF ISOPOD CRUSTACEA.

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NOTE ON A TRANSFORMATION AND ON THE DIFFERENTIATION OF A CONTINUED FRACTION.

By Sir Thomas Muir, F.R.S.

1. In a very interesting paper of 1916 * dealing with the continued fraction

$$\frac{1}{b+x-}\,\frac{a_1}{b_1+x-}\,\frac{a_2}{b_2+x-}\cdots-\frac{a_n}{b_n+x}$$

Professor Whittaker in the first place obtains as an equivalent for the fraction a series in descending powers of x, his result being

$$\frac{1}{x}-\frac{A_1}{x^2}+\frac{A_2}{x^3}-\frac{A_3}{x^4}+\ \ldots\ldots$$

where A_r is the $(1,1)^{\text{th}}$ or leading term of the r^{th} power of the continuant

$$\begin{vmatrix} b & a_1 & . & . & \ldots \\ 1 & b_1 & a_2 & . & \ldots \\ . & 1 & b_2 & a_3 & \ldots \\ . & . & 1 & b_3 & \ldots \\ . & . & . & . & \ldots \end{vmatrix}_{n+1,} \quad \text{or K say.}$$

A formal demonstration is given, based on the use of a linear substitution and on Cayleyan matrices; also, the lines are sketched of a second mode of proof which opens differently, but into which again in the end the theory of matrices enters.

It is of some real interest, and especially to students of determinants, to ascertain whether the problem here solved cannot be satisfactorily treated without the introduction of this theory: and, at any rate, an alternative mode of treatment cannot but be helpful.

* Proc. Roy. Soc. Edin., xxxvi, pp. 243–255.

2. *The continued fraction in question is expressible in the form*

$$\frac{1}{x}-\frac{A_1}{x^2}+\frac{A_2}{x^3}- \ldots .$$

if A_r *is the recurrent*

$$\begin{vmatrix} S_1-\sigma_1 & 1 & . & . & \ldots \\ S_2-\sigma_2 & S_1 & 1 & . & \ldots \\ S_3-\sigma_3 & S_2 & S_1 & 1 & \ldots \\ . & . & . & . & \ldots \end{vmatrix}_r ,$$

and S_t *is the sum of the* t*-line coaxial minors of the continuant referred to, and* σ_t *is the corresponding sum in the case of the cofactor of* b *in the continuant.* For example, when n is 2 we have

$$\frac{1}{b+x-}\frac{a_1}{b_1+x-}\frac{a_2}{b_2+x} = \begin{vmatrix} b_1+x & a_2 \\ 1 & b_2+x \end{vmatrix} \div \begin{vmatrix} b+x & a_1 & . \\ 1 & b_1+x & a_2 \\ . & 1 & b_2+x \end{vmatrix}$$

$$= \frac{x^2+\sigma_1 x+\sigma_2}{x^3+S_1x^2+S_2x+S_3}$$

$$= \frac{1}{x}-\frac{S_1-\sigma_1}{x^2}+\frac{\begin{vmatrix} S_1-\sigma_1 & 1 \\ S_2-\sigma_2 & S_1 \end{vmatrix}}{x^3} - \ldots ;$$

and, since

$$\sigma_1=b_1+b_2, \qquad \sigma_2=b_1b_2-a_2,$$
$$S_1=b+b_1+b_2, \quad S_2=bb_1+bb_2+b_1b_2-a_1-a_2,$$

this series becomes simply

$$x^{-1}-bx^{-2}+(b^2+a_1)x^{-3}- \ldots .$$

3. It will be observed that the two expressions thus available for A_r are very unlike, the one demanding the raising of a continuant to the r^{th} power, and the other the evaluation of an r-line recurrent. As for ease of application to specialised cases there is less difference between the two than one might at first imagine: and something better than either in this respect is desirable. Let us examine therefore the possibility of simplifying the recurrent

$$\begin{vmatrix} S_1-\sigma_1 & 1 & . & \ldots \\ S_2-\sigma_2 & S_1 & 1 & \ldots \\ . & . & . & \ldots \end{vmatrix} .$$

4. The first step in the direction of simplification is to utilise the fact

that it can be made entirely persymmetric. The operation necessary for this is the diminishing of each row, the m^{th} say, by

$$\sigma_1 \,\text{row}_{m-1} + \sigma_2 \,\text{row}_{m-1} + \ \ldots\ldots ;$$

and the good derived from the operation is that when we have so simplified A_m we know also all the simplified elements of A_{m+1} save the first element of its last row. For example, having found above that

$$A_2 = \begin{vmatrix} b & 1 \\ -a_1 & b \end{vmatrix}, \text{ we know that } A_3 = \begin{vmatrix} b & 1 & . \\ -a_1 & b & 1 \\ ? & -a_1 & b \end{vmatrix},$$

the only unknown element being the $(3,1)^{\text{th}}$: and on this element being found to be a_1b_1 we know similarly that

$$A_4 = \begin{vmatrix} b & 1 & . & . \\ -a_1 & b & 1 & . \\ a_1b_1 & -a_1 & b & 1 \\ ? & a_1b_1 & -a_1 & b \end{vmatrix}.$$

The next step is to utilise the fact that, since in the preceding work the operations have been entirely confined to rows, it follows that any desired element of the first column can be calculated from the elements preceding it in that column,—in fact, must be an aggregate of multiples of the said elements. Our next desideratum is thus to find the series of multipliers requiring to be used in order to obtain the aggregate. With a little trouble each multiplier could be pursued and captured separately: and no better mode seemed available until it was observed that the procedure followed had a look quite similar to that for obtaining separately the elements themselves. This immediately led to the curious result: *If the first* m *simplified elements of* A_r *be known, the multipliers necessary to find the* $(m+1)^{th}$ *element are got from the first* $m-1$ *already calculated by altering the signs and increasing each suffix by* 1. For example, having found the simplified elements of the first column of A_4 to be

$$b, \quad -a_1, \quad a_1b_1, \quad -a_1(b_1^2+a_2)$$

we derive from the first three of them the multipliers

$$-b, \quad a_2, \quad -a_2b_2,$$

and thence obtain the element

$$\begin{aligned}(5,1) &= (4,1)\times(-b_1) + (3,1)\times a_2 + (2,1)\times(-a_2b_2) \\ &= a_1(b_1^2+a_2)b_1 + a_1b_1a_2 + a_1a_2b_2 \\ &= a_1b_1^3 + 2a_1a_2b_1 + a_1a_2b_2.\end{aligned}$$

There is thus fully known a third expression for the coefficient of $1/x^{r+1}$ in our series, namely,

$$\mathrm{A}_r = \left|\begin{array}{cccccccc} b & 1 & . & . & . & . & . & . \\ -a_1 & b & 1 & . & . & . & . & . \\ a_1b_1 & -a_1 & b & 1 & . & . & . & . \\ -a(b_1^2+a_2) & a_1b_1 & -a_1 & b & . & . & . & . \\ . & . & . & . & . & . & . & . \end{array}\right|_r.$$

5. Of course the question at once arises as to how the persymmetric determinant whose first column is

$$b, \quad -a_1, \quad a_1b_1, \quad -a_1(b_1^2+a_2), \quad . \; . \; . \; .$$

can be the equivalent of the $(1,1)^{\text{th}}$ element of the r^{th} power of

$$\left|\begin{array}{ccccccc} b & a_1 & . & . & . & . & . \\ 1 & b_1 & a_2 & . & . & . & . \\ . & 1 & b_2 & . & . & . & . \\ . & . & . & . & . & . & . \end{array}\right|_{n+1}.$$

The latter expression thus deserves further consideration.

6. The only general method as yet given for guidance in raising a determinant to a power is by means of bipartite functions,* in the notation of which the product $|\,h_1k_2\,| \cdot |\,p_1q_2\,| \cdot |\,x_1y_2\,|$ is

$$\left|\begin{array}{cc} \begin{array}{cc|c} h_1 & h_2 & \\ \hline p_1 & q_1 & x_1 \\ p_2 & q_2 & y_1 \end{array} & \begin{array}{cc|c} h_1 & h_2 & \\ \hline p_1 & q_1 & x_2 \\ p_2 & q_2 & y_2 \end{array} \\ & \\ \begin{array}{cc|c} k_1 & k_2 & \\ \hline p_1 & q_1 & x_1 \\ p_2 & q_2 & y_1 \end{array} & \begin{array}{cc|c} k_1 & k_2 & \\ \hline p_1 & q_1 & x_2 \\ p_2 & q_2 & y_2 \end{array} \end{array}\right|$$

with the appropriate alteration when the product changes into a power. By this means any individual element can without reference to the others be specified and evaluated, the properties of bipartites being utilised to simplify the calculation when the power increases. For example,

$$\mathrm{A}_2 = \begin{array}{cc} b & a_1 \\ \hline b & 1 \end{array} = b^2+a_1, \qquad \mathrm{A}_3 = \begin{array}{cc|c} b & a_1 & \\ \hline b & 1 & b \\ a_1 & b_1 & 1 \end{array} = b^3+2ba_1+a_1b_1,$$

* Trans. Roy. Soc. Edin., xxxii, pp. 461–482.

$$A_4=\begin{array}{ccc|ccc} b & a_1 & . & & & \\ \hline b & 1 & . & b & a_1 & . \\ a_1 & b_1 & 1 & 1 & b_1 & a_2 \\ . & a_2 & b_2 & . & 1 & b_2 \\ \hline & & & b & 1 & . \end{array} =b^4+3b^2a_1+2bb_1a_1+b_1^2a_1+a_1^2+a_1a_2,$$

and generally $A_r=\begin{array}{c|c} b\ \ a_1 & \\ \hline K^{r-2} & \begin{matrix} b \\ 1 \end{matrix} \end{array}$ or $\dfrac{b\ \ a_1 \mid b\ \ 1}{K^{r-2}}$.

Now to show that A_r'', the persymmetric determinant, is identical with A_r''', the bipartite, what we have got to do is to expand the former by the recurrence-formula of determinants and the latter repeatedly by the corresponding formula of bipartites. Thus, when r is 4, we already know that

$$A_4''=bA_3''+a_1A_2''+a_1b_1A_1''+a_1(b_1^2+a_2):$$

and expanding

$$\begin{array}{cc|cc} b & a_1 & & \\ \hline b & 1 & b & a_1 \\ a_1 & b_1 & 1 & b_1 \\ . & a_2 & . & 1 \\ \hline & & b & 1 \end{array}$$

in terms of b, a_1 and their cofactors, we obtain

$$A_4'''=bA_3'''+\begin{array}{c|cc} a_1 & & \\ \hline 1 & b & a_1 \\ b_1 & 1 & b_1 \\ a_2 & . & 1 \\ \hline & b & 1 \end{array}$$

$$=bA_3'''+a_1A_2'''+\begin{array}{c|cc} a_1 & & \\ \hline b_1 & 1 & b_1 \\ a_2 & . & 1 \\ \hline & b & 1 \end{array}$$

$$=bA_3'''+a_1A_2'''+a_1b_1A_1'''+a_1b_1^2+a_1a_2,$$

and this agrees.

It must be added, however, that the bringing of the second development into line with the first increases in complexity as r increases.

7. Let us turn now to the differentiation of the continued fraction.

Using the same means as before, Professor Whittaker finds that the negative differential-quotient of

$$\frac{1}{b+x-\frac{a_1}{b_1+x-\cdots-\frac{a_n}{b_n+x}}}$$

is the leading element in the determinant reciprocal to the square of the continuant K: and in addition, he shows that the said leading element is equal to a fraction whose denominator is K^2 and whose numerator is the cofactor of the leading element in K^2.

8. In regard to this I think it is worth noting that the numerator of the result being the product of two arrays, namely, the array got from K by deleting its first row and the similar array got by deleting its first column, there is considerable advantage in viewing it in this light. For example, if n be 3, the better form of numerator is

$$\left\| \begin{array}{cccc} 1 & b_1+x & a_2 & . \\ . & 1 & b_2+x & a_3 \\ . & . & 1 & b_3+x \end{array} \right\| \quad \left\| \begin{array}{cccc} a_1 & b_1+x & 1 & . \\ . & a_2 & b_2+x & 1 \\ . & . & a_3 & b_3+x \end{array} \right\|$$

or

$$L^2+a_1M^2+a_1a_2N^2+a_1a_2a_3,$$

where L is the first primary minor of K, M the first primary minor of L, and N the first primary minor of M.

9. The proof, then, is quite a simple matter, for, the fraction to be differentiated being L/K, the numerator of the negative differential-quotient is

$$-K\frac{\partial L}{\partial x}+L\frac{\partial K}{\partial x};$$

and this on substituting $(b+x)L-a_1M$ for K

$$= -\left\{(b+x)L-a_1M\right\}\frac{\partial L}{\partial x} + L\left\{L+(b+x)\frac{\partial L}{\partial x}-a_1\frac{\partial M}{\partial x}\right\}$$

$$= L^2+a_1M\left\{M+(b_1+x)\frac{\partial M}{\partial x}-a_2\frac{\partial N}{\partial x}\right\}-\left\{(b_1+x)M-a_2N\right\}a_1\frac{\partial M}{\partial x}$$

$$= L^2+a_1M^2-a_1a_2\left\{(b_2+x)N-a_3\right\}\frac{\partial N}{\partial x}+a_1a_2N\left\{N+(b_2+x)\frac{\partial N}{\partial x}\right\}$$

$$= L^2+a_1M^2+a_1a_2N^2+a_1a_2a_3,$$

a simplification being accompanied by a substitution in each line till the close.

10. Lastly, it is important to note that both the theorems touched on in the foregoing hold not only when the fraction dealt with is of the form

$$\begin{vmatrix} b_1+x & a_2 \\ 1 & b_2+x \end{vmatrix} \div \begin{vmatrix} b+x & a_1 & . \\ 1 & b_1+x & a_2 \\ . & 1 & b_2+x \end{vmatrix}$$

and is therefore equal to a continued fraction, but also when it is of the form

$$\begin{vmatrix} \beta_2+x & \beta_3 \\ \gamma_2 & \gamma_3+x \end{vmatrix} \div \begin{vmatrix} a_1+x & a_2 & a_3 \\ \beta_1 & \beta_2+x & \beta_3 \\ \gamma_1 & \gamma_2 & \gamma_3+x \end{vmatrix}$$

—that is to say, when any quite general determinant $| a_1\beta_2\gamma_3 \ldots . |$ takes the place of the continuant K. Indeed, the first of the theorems in this general form was established by me so long ago as 1885 in a paper not occupied with continued fractions at all.*

RONDEBOSCH, S.A.,
10th July 1924.

* The subject of the paper was "New Relations between Bipartite Functions and Determinants, with a Proof of Cayley's Theorem on Matrices"; and it was published in the Proc. London Math. Soc., xvi, pp. 276–286. The *reciprocal* of the fraction is also there expanded in like fashion.

COLOUR AND CHEMICAL CONSTITUTION.

Part XIX.—Organic Fluorescence.

By James Moir.

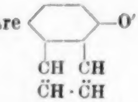
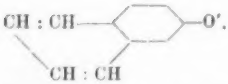
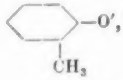
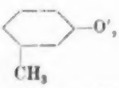
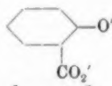
This series of papers would not be complete without some discussion of fluorescence as it occurs in organic compounds. The unique case of inorganic fluorescence has already been investigated in Part VIII of this series (1919), and therein put on a mathematical basis. In the case of the fluorescence of organic substances it is hopeless to expect such a satisfactory result, inasmuch as the fluorescence-colour when analysed by the spectroscope is found to consist of a very broad band of extremely indefinite average wave-length, so indefinite that no search for a mathematical basis is possible with such data.

As in the case of colour, the origin of fluorescence is to be sought (by means of investigations in the ultra-violet) by comparing the chemical constitutions of very simple substances.

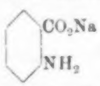
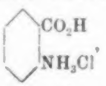
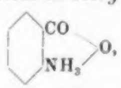
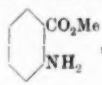
The first point is the connection between aromatic rings and fluorescence. No substance *fluoresces* unless it contains an aromatic ring, whereas a number of substances possess *colour* without an aromatic ring or even without a ring of any sort, *e.g.* the violurates, sodium aceto-acetic ester, $Me_3C \cdot NO$, etc. On the other hand, the majority of substances possessing an aromatic ring do *not* fluoresce, although practically all absorb ultra-violet light, and do so with a sharp absorption-band. Benzene itself does not fluoresce, nor does phenol, but a benzene solution of quinol has a violet fluorescence in strong light. The other two isomers of quinol do not fluoresce appreciably, whence it follows that in addition to the aromatic ring there is a second factor required consisting in the *nature* and *arrangement* of the groups attached to the ring. As regards the *nature* of such groups, it is apparently necessary that one of these shall be an auxochrome, as defined in Part XVII (p. 278, § 3), when only one aromatic ring is present; but if two aromatic rings are present, no auxochrome is necessary and fluorescence appears whenever the two rings are joined at two places by two groups of almost any sort. The *arrangement* of the groups attached to the aromatic ring (when there is only one ring) is probably less important than their nature; bright fluorescence goes with the *ortho* and *para* positions, but faint

fluorescences are known in substances having their groups in the *meta* position (*e.g.* metanitrodimethyl-aniline).

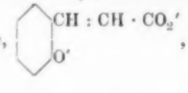
That the problem of organic fluorescence is considerably more difficult than that of organic colour is shown by the following examples of fluorescing substances :—

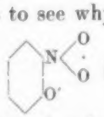
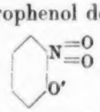
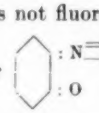
A. *The Naphthols in Aqueous Alkali.*—The formulæ are  and . Sodium phenoxide, , does not fluoresce, neither does alkaline orthocresol, , nor metacresol, , nor paracresol, . On the other hand, alkaline sodium salicylate, of which the ion is , fluoresces markedly—whereas the *para* and *meta* isomerides do not fluoresce.

B. *All Anthranilic Acid Derivatives in every Medium.*—The formulæ are

, , , and ,

according as it is alkaline, acid, neutral, or ester.

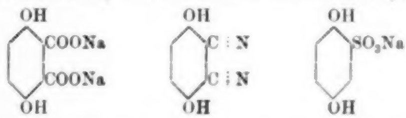
It is easy from these examples to say what is *not* the cause of fluorescence, *e.g.* (1) the co-operation of two *ortho* groups, or (2) the formation of a side ring between two *ortho* groups. In the compounds with two *ortho* groups it is apparently necessary for fluorescence that one group shall be an auxochrome and that the other shall contain an unsaturation attached to the element nearest the ring. In addition to α-naphthol and sodium salicylate we have the case of sodium cumarate, , as a fluorescing substance of this type.

It is, however, difficult to see why orthonitrophenol does not fluoresce (unless it has the formula  instead of  or ), and it is also hard to see why it is only the *ortho* (and not the *para* and *meta*) arrangement of auxochrome and unsaturation that goes with fluorescence. Probably the difference is spatial, and this will be referred to later on, but

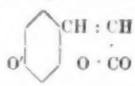
it is here to be noted that the two oxygens of quinol are nearer together than those of catechol or resorcinol, and that the oxygen of metanitrodimethylaniline is probably quite close to the amine-nitrogen—these facts giving an explanation of the fluorescence of these substances although they are neither ortho-compounds nor composed of auxochrome plus unsaturation.*

The other fluorescing derivatives of benzene are less simple than the cases considered, and do not throw light on the problem, inasmuch as several alternative factors come into play at once.

The derivatives of quinol described in Part XVI, p. 236, and others described by Kaufmann (Berichte, 1908, 4422, and earlier papers), do indeed possess fluorescence as striking as that of fluorescein and rhodamine—in spite of their comparatively simple constitution. In these, however, the greatly enhanced effect is to be attributed to the co-operation of two pairs of factors which are essentially the same as in sodium salicylate :—



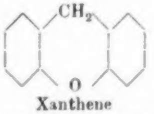
Also in umbelliferone, another substance of extraordinary fluorescence, we have the combination of two separate pairs of factors each of which is capable of causing fluorescence, viz. (1) cumaric acid *per se* (see p. 46), and (2) the *para* combination of hydroxyl and unsaturation :—



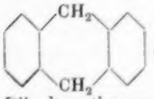
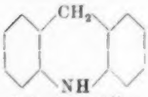
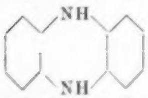
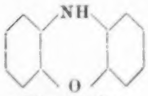
Fluorescent Substances containing Two Aromatic Rings.—These, as already said, are especially interesting because they exhibit fluorescence without possessing any auxochromes. It is only necessary that the rings be doubly united. In certain cases the fluorescence is only exhibited in concentrated sulphuric acid solution and in others only in the solid state.

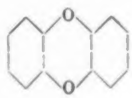
The following table gives my observations on these substances :—

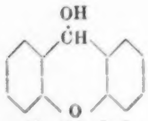
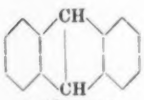
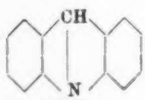
TABLE.

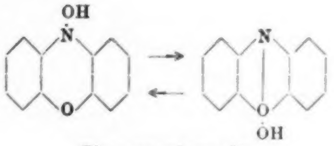
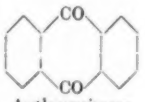
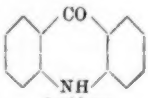
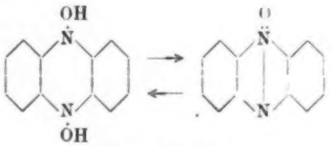
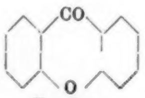
Name and Constitutional Formula.	Fluorescence in H_2SO_4 conc.	Position of absorption-bands by transmitted light on same solution.
1.  Xanthene	Brilliant yellow-green	λλ 360 strong and 425 weak.

* Unsaturation in the nitro-group is excluded by the case of orthonitrophenol mentioned above.

	Name and Constitutional Formula.	Fluorescence in H_2SO_4 conc.	Position of absorption-bands by transmitted light on same solution.
2.	 Dihydroanthracene	Blue-violet	λλ 352 and 400.
3.	 Dihydroacridine	Brilliant green	λλ 430 and 408 narrow, and 340 broad.
4.	 Dihydrophenazine	Very weak grey-green	λ 398 broad.
5.	 Phenoxazine	Green	λ 417.

The substance  required for completion is still unknown.

6.	 Xanthhydrol	Very faint blue	λ 450, plus λ 470 weak.
7.	 Anthracene	Practically none	λ 330 broad.
8.	 Acridine	Bright bluish green	λ 355 narrow.
9.	 Phenazine	Weak grey-green	λ 510, plus λ 550 weak.

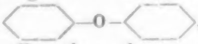
	Name and Constitutional Formula.	Fluorescence in H_2SO_4 conc.	Position of absorption-bands by transmitted light on same solution.
10.	 Phenoxazonium salts	Practically none	λ 460.
11.	 Anthraquinone	None (or exceedingly faint orange)	λ 403 broad.
12.	 Acridone	Brilliant "electric" blue	λλ 336 and 358, both narrow.
13.	 Phenazine-oxide	Very faint orange	λλ 501 and 544.
14.	 Xanthone	Bright violet	λλ 340 and 405.

In addition, the green solution from anthracene and dihydroanthracene in H_2SO_4 (probably a quinhydrone) was examined. This has λ 701 * with a faint red fluorescence. The corresponding quinhydrone of dihydrophenazine (see Part XVI, p. 237) probably has an absorption-band above λ 760 in H_2SO_4 solution. The corresponding quinhydrone of phenoxazine has λ 537 in H_2SO_4 (Kehrmann gives λ 530).

It is of considerable theoretical interest to note that there is no possible way of assigning a quinonoid constitution to the solution of xanthene in H_2SO_4, and it appears to be quite clear that the fluorescence depends, not

* Fainter bands at λλ 569, 653, 556, 619, 525, 515, and 603 were also seen in thicker layers of this solution—an extraordinary phenomenon. All disappear on keeping.

on unsaturation outside the ring, but wholly on the rings as such with the presence of two groups holding them in a *rigid* position, *i.e.* on purely spatial considerations. It also fluoresces in benzene solution, but not strongly.

Possibly fluorescence is merely the reflection of light from such rigid molecules acting as mirrors, and only such molecules as are devoid of rigidity, *e.g.* , are non-fluorescent. As the "mirrors" are much smaller than the waves of light, the reflection is affected by diffraction-phenomena, giving a change of colour.

A BIBLIOGRAPHIC LIST OF PRE-STORMBERG KARROO REPTILIA, WITH A TABLE OF HORIZONS.

By S. H. Haughton, B.A., D.Sc.

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This list contains references to the chief literature dealing with each of the species of pre-Stormberg Karroo Reptilia. The Stormberg fauna is omitted, since full references were given in the author's paper on the fossils from that series (Ann. S. Afr. Mus., xii, 1924). It has been felt that such a list may be of assistance to those working at this most interesting assemblage of forms. The number of genera and species has of recent years increased rapidly, and the descriptions have appeared in a number of scientific periodicals. To gather together this literature is the first necessary step in making a survey of the fauna.

The types are distributed among various collections in and outside South Africa. Some of them are fragmentary and can throw little light upon the larger questions of classification and development; a few are probably unidentifiable and must remain as tantalising curiosities of nomenclature. Of the well-defined forms much still remains to be done in the way of study and description in order that details may be added to the outline picture that is being gradually drawn.

Super-Order COTYLOSAURIA (Cope).

Order DIADECTOMORPHA, Watson.

Sub-Order Pareiasauria.

Genus anthodon, Owen.

Anthodon serrarius, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 14, pl. xiii.
1910. Broom, Trans. Roy. Soc. S. Afr., ii, p. 24.
1914. Watson, P.Z.S., p. 165.
1914. ,, Ann. Mag. Nat. Hist., xiv, p. 101.

Type: a badly preserved, incomplete skull in the British Museum.

Genus BRADYSAURUS, Watson.

Bradysaurus baini (Seeley).

1892. Seeley, *Pareiasaurus baini*, Phil. Trans., B, 183, p. 311, pls. xvii–xxiii.
1895. ,, *P. baini*, Geol. Mag., p. 1, pl. i.
1913. Broom, ,, Ann. S. Afr. Mus., vii, p. 353, figs. 1, 2.
1914. Watson, Ann. Mag. Nat. Hist., xiv, No. 79, p. 101.
Type: skeleton in the British Museum.

Bradysaurus bombidens (Owen).

1876. Owen, *Pareiasaurus bombidens*, Cat. Foss. Rept. S. Afr., p. 9, pl. viii, 3; ix.
1888. Seeley, *P. bombidens*, Phil. Trans., B, 179, p. 59, pls. xii–xx (not xvi).
1892. ,, ,, Phil. Trans., B, 183, pl. xx.
1924. Broom, P.Z.S., p. 501, figs. 2–4, 6B.
Type: forepart of a skull in the British Museum. The assignation of this species to *Bradysaurus* is not certain. Moreover, it is possible that the specimen described by Seeley does not belong to this species.

Bradysaurus whaitsi (Broom).

1914. Broom, *Pareiasaurus whaitsi*, Amer. Mus. Journ., xiv, p. 138, fig.
1915. ,, ,, ,, Bull. Amer. Mus. Nat. Hist., xxv, p. 109, fig. 1.
Type: a skull and lower jaw in the American Museum of Natural History. It is not certain that this species belongs to *Bradysaurus*. The Pareiasauria from the Lower Beaufort Beds stand in need of systematic revision.

Genus EMBRITHOSAURUS, Watson.

Embrithosaurus schwarzi, Watson.

1904. Broom, *Pareiasaurus serridens*, Ann. S. Afr. Mus., iv, p. 123, pls. xv, xvi.
1914. Watson, "*Pariasaurus*," P.Z.S., p. 156, figs. 1–6.
1914. ,, Ann. Mag. Nat. Hist., xiv, No. 79, p. 102.
Type: a skeleton in the South African Museum.

Genus PAREIASAURUS, Owen.

Pareiasaurus serridens, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 6, pls. vi, vii.
1888. Seeley, Phil. Trans., B, 179, p. 75, pl. xvi.
Type: cast of a skull, part of lower jaw, pelvis, scapula, vertebrae, and scutes in the British Museum.

Genus doubtful

"*Pareiasaurus*" *struberi*, Broom.

1924. Broom, P.Z.S., p. 508, figs. 5, 6A.
Type: lower jaw in coll. Dr. R. Broom.

Genus PAREIASUCHUS, Broom and Haughton.

Pareiasuchus peringueyi, Broom and Haughton.

1913. Broom and Haughton, Ann. S. Afr. Mus., xii, p. 17, pls. iii, iv.
Type: skeleton in the South African Museum.

Genus PROPAPPUS, Seeley.

Propappus omocratus, Seeley.

1876. Owen, *Dicynodon tigriceps* (pars), Cat. Foss. Rept. S. Afr., p. 40, pls. xxxvi, xxxvii.
1890. Seeley, Proc. Roy. Soc., xliv, No. 267.
1892. „ *Pareiasaurus* (*Propappus*) *minor*, Phil. Trans., B, 183, p. 354, figs. 10, 11.
1908. Broom, Ann. S. Afr. Mus., iv, p. 351, pl. xlv.
Type: a femur, sacrum, pelvis, and part of humerus in the British Museum.

Propappus parvus, Haughton.

1913. Haughton, Ann. S. Afr. Mus., xii, p. 43, pl. iv, 5.
Type: pelvis with associated vertebrae in the South African Museum.

Propappus rogersi, Broom.

1912. Broom, Ann. S. Afr. Mus., xii, p. 323, pls. xix–xxi.
Type: vertebrae, girdles, and limb-bones in the South African Museum.

Propappus roussowi (Seeley).

1892. Seeley, *Pareiasaurus roussowi*, Phil. Trans., B, 183, p. 333, pl. xix, 3–4.
Type: fragments of jaw in British Museum. The generic position is doubtful.

Propappus ? acutirostris (Broom).

1913. Broom, *Pareiasaurus acutirostris*, Rec. Albany Mus., ii, p. 397.
Type: a skull in the Albany Museum.

Sub-Order PROCOLOPHONIA.

Genus procolophon, Owen.

Procolophon trigoniceps, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 25, pl. xx, 4–7.
1889. Seeley, Phil. Trans., B, 180, p. 269, pl. ix, 7–9.
1892. ,, ,, ,, B, 183, p. 364, pl. xxiii, 3.
1903. Osborn, Mem. Amer. Mus. Nat. Hist., i, p. 479, fig. 14, *a*, *b*.
1903. Broom, Rec. Albany Mus., i, p. 8, pl. i, 3–5.
1904. ,, ,, ,, ,, i, p. 88.
1904. ,, Trans. S. Afr. Phil. Soc., xv, pl. 89, pl. vii, 7.
1905. Seeley, P.Z.S., p. 218.
1914. Watson, P.Z.S., p. 735, pls. i–iii and figs. 1–5.
1921. Broom, P.Z.S., p. 146, fig. 7.
Type: a skull in the British Museum.

Genus thelegnathus, Broom.

Thelegnathus browni, Broom.

1905. Broom, Rec. Albany Mus., i, p. 274.
Type: fragment of jaw, with the teeth, in South African Museum.

Thelegnathus parvus, Broom.

1905. Broom, Rec. Albany Mus., i, p. 275.
Type: small fragment of jaw, with molars, in South African Museum.

Super-Order THERAPSIDA, Broom.

Order DINOCEPHALIA, Seeley.

Sub-Order Tapinocephalia, Broom.

Genus delphinognathus, Seeley.

Delphinognathus conocephalus, Seeley.

1892. Seeley, Quart. Journ. Geol. Soc., xlviii, p. 469.
1910. Broom, Bull. Amer. Mus. Nat. Hist., xxviii, p. 206, fig. 4.
Type: incomplete skull in South African Museum.

Genus eccasaurus, Broom.

Eccasaurus priscus, Broom.

1909. Broom, Ann. S. Afr. Mus., vii, p. 276.
1912. ,, P.Z.S., pl. xc, fig. 2 (?).
Type: a humerus in the South African Museum.

Genus MORMOSAURUS, Watson.

Mormosaurus seeleyi, Watson.

1901. Broom, *Tapinocephalus atherstonei*, Geol. Mag., p. 400.
1914. Watson, P.Z.S., p. 767, pl. iv, and figs. 1–4.
1919. „ „ p. 298, fig. 15H.

Type: a skull in the British Museum.

Genus MOSCHOGNATHUS, Broom.

Moschognathus whaitsi, Broom.

1914. Broom, Bull. Amer. Mus. Nat. Hist., xxxiii, p. 137, fig. 2.
1914. „ Phil. Trans., B, 206, p. 42, pl. ii, 24, 27.

Type: lower jaw and part of upper jaw, with teeth, and other remains, in the American Museum of Natural History.

Genus MOSCHOPS, Broom.

Moschops capensis, Broom.

1911. Broom, P.Z.S., p. 1073, pl. lxii, fig. 1.
1914. „ Bull. Amer. Mus. Nat. Hist., xxxiii, p. 140, figs. 5–7.
1914. „ Phil. Trans., B, 206, p. 42, pl. i, 1–11, pl. ii, 12–23, 25, 26, 28.
1922. Romer, Bull. Amer. Mus. Nat. Hist., xlvi, pls. 27–36, 38–45.

Type: a weathered and crushed skull in the American Museum of Natural History.

Genus PELOSUCHUS, Broom.

Pelosuchus priscus, Broom.

1905. Broom, Rec. Albany Mus., i, p. 335.

Type: a very fragmentary skeleton in the South African Museum.

Genus PHOCASAURUS, Seeley.

Phocasaurus megischion, Seeley.

1888. Seeley, Phil. Trans., B, 179, p. 91, pl. xxi, 1.
1914. Watson, P.Z.S., p. 763, figs. 11, 13.

Type: vertebrae and portions of the girdles and front limbs in the British Museum.

Genus PNIGALION, Watson.

Pnigalion oweni, Watson.

1914. Watson, P.Z.S., p. 767, figs. 5, 6, 7, 12, 14, 16A.

Type: a skull lacking snout, with dentaries and some limb-bones, in the British Museum.

Genus STRUTHIOCEPHALUS, Haughton.

Struthiocephalus whaitsi, Haughton.

1915. Haughton, Ann. S. Afr. Mus., xii, p. 52, pl. x.
Type: skull in South African Museum.

Genus TAPINOCEPHALUS, Owen.

Tapinocephalus atherstonei, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 1, pls. i–v.
1913. Haughton, Ann. S. Afr. Mus., xii, p. 40, figs. 4, 5.
1915. Broom, Bull. Amer. Mus. Nat. Hist., xxv, p. 112, fig. 3.
Type: anterior end of snout in the British Museum.

Genus TAUROPS, Broom.

Taurops macrodon Broom.

1912. Broom, P.Z.S., p. 859, pl. xc, 1.
Type: a snout in the American Museum of Natural History.

Sub-Order TITANOSUCHIA, Broom.

Family TITANOSUCHIDAE, Broom.

Genus ANTEOSAURUS, Watson.

Anteosaurus magnificus, Watson.

1910. Broom, *Titanosuchus ferox*, Trans. Roy. Soc. S. Afr., ii, p. 21, fig. 1.
1914. Watson, ,, ,, P.Z.S., p. 770, figs. 17, 18, and pl v.
1921. ,, P.Z.S., p. 91, fig. 28.
Type: a skull in the British Museum.

Genus DINOPHONEUS, Broom.

Dinophoneus ingens, Broom.

1923. Broom, P.Z.S., p. 666, figs. 4–7.
Type: a nearly complete skull in coll. Dr. Broom.

Genus ENOBIUS, Broom.

Enobius strubeni, Broom.

1923. Broom, P.Z.S., p. 683, fig. 17.
Type: two dentaries in coll. Dr. Broom.

Genus JONKERIA, v. Hoepen.

Jonkeria truculens, v. Hoepen.

1916. van Hoepen, Ann. Transv. Mus., v, 3, suppl. 3.
Type: skull and partial skeleton in Transvaal Museum.

Genus LAMIASAURUS, Watson.

Lamiasaurus newtoni, Watson.

1914. Watson, P.Z.S., p. 768, figs. 8, 9.
1921. ,, ,, p. 93.
1923. Broom, ,, p. 662.
Type: a snout in the British Museum.

Genus SCAPANODON, Broom.

Scapanodon duplessisi, Broom.

1904. Broom, Rec. Albany Mus., i, p. 182.
1923. ,, P.Z.S., p. 663, figs. 1–3.
Type: jaw fragments, with teeth, in the South African Museum.

Genus TITANOSUCHUS, Owen.

Titanosuchus cloetei, Broom.

1903. Broom, Ann. S. Afr. Mus., iv, p. 142.
1923. ,, P.Z.S., p. 676, figs. 11–13.
Type: front portion of left mandible in South African Museum.

Titanosuchus dubius, Haughton,

1915. Haughton, Ann. S. Afr. Mus., xii, p. 57.
Broom (1923) suggests that this may be a synonym of *T. cloetei*. Type: portion of mandible in South African Museum.

Titanosuchus ferox, Owen.

1879. Owen, Quart. Journ. Geol. Soc., xxxv, p. 189, pl. xi.
1889. Seeley, Phil. Trans., B, 180, p. 258, pl. xvi, 4, xix, xx, xxiv, 1, 2.
1903. Broom, Ann. S. Afr. Mus., iv, p. 144.
Type: fragmentary jaw in British Museum.

Family DINARTAMIDAE, Broom.

Genus DINARTAMUS, Broom.

Dinartamus vanderbyli, Broom.

1923. Broom, P.Z.S., p. 669, figs. 8–9.

Type: skull fragments in coll. Dr. Broom.

Family MOSCHOSAURIDAE, nov.

Genus MOSCHOSAURUS, Haughton.

Moschosaurus longiceps, Haughton.

1915. Haughton, Ann. S. Afr. Mus., xii, p. 76, figs. 8, 9.

Type: skull and lower jaw, with associated vertebrae, in South African Museum.

ORDER DROMASAURIA, Broom.

Family GALECHIRIDAE, nov.

Genus GALECHIRUS, Broom.

Galechirus scholtzi, Broom.

1907. Broom, Trans. S. Afr. Phil. Soc., xviii, p. 31, pl. iii, 1–5.
1914. ,, Phil. Trans., B, 206, p. 12, pl. iii, 29, pl. iv, 35, 37–39.

Type: skeleton in South African Museum.

Genus GALEPUS, Broom.

Galepus jouberti, Broom.

1910. Broom, Bull. Amer. Mus. Nat. Hist., xxviii, p. 204, fig. 3.
1914. ,, Phil. Trans., B, 206, p. 13, pl. iii, 28, pl. iv, 31–33, 36.
1915. ,, Bull. Amer. Mus. Nat. Hist., xxv, p. 114, figs. 4, 5.

Type: nearly complete skeleton left as an impression in sandstone in American Museum of Natural History.

Family GALEOPSIDAE, Broom.

Genus GALEOPS, Broom.

Galeops whaitsi, Broom.

1912. Broom, P.Z.S., p. 860, pl. xci, 6.
1914. ,, Phil. Trans., B, 206, p. 14, pl. iii, 30, pl. iv, 34.
1915. ,, Bull. Amer. Mus. Nat. Hist., xxxv, p. 114.

Type: skull and anterior half of skeleton in American Museum of Natural History.

Family MACROSCELESAURIDAE, nov.

Genus MACROSCELESAURUS, Haughton.

Macroscelesaurus janseni, Haughton.

1918. Haughton, Ann. S. Afr. Mus., xii, p. 175, fig. 45.
Type: impression of partial skeleton in sandstone in South African Museum.

ORDER ANOMODONTIA, Owen.

Family DICYNODONTIDAE.

Genus BAINIA, Broom.

Bainia haughtoni, Broom.

1917. Haughton, *Dicynodon laticeps* (pars), Ann. S. Afr. Mus., xii, p. 144, fig. 34.
1921. Broom, P.Z.S., p. 661, fig. 38.
Type: an incomplete immature skull in the South African Museum.

Bainia laticeps (Broom).

1912. Broom, *Dicynodon laticeps*, P.Z.S., p. 868, pl. xcii, 12, 13.
1915. „ „ „ Bull. Amer. Mus. Nat. Hist., xxv, p. 131, fig. 17.
1917. Haughton, „ „ Ann. S. Afr. Mus., xii, p. 144.
Type: skull in American Museum of Natural History.

Bainia peavoti, Broom.

1921. Broom, P.Z.S., p. 659, fig. 37.
Type: skull in coll. Dr. Broom.

Bainia tigriceps (Owen).

1855. Owen, *Dicynodon tigriceps*, Trans. Geol. Soc., vii, ser. 2, p. 233.
1876. „ „ „ and *D. baini*, Cat. Foss. Rept. S. Afr., p. 36, pls. xxx–xxxv.
1889. Seeley, „ „ Phil. Trans., B, 180, p. 236, pl. xiii.
1917. Haughton, „ „ Ann. S. Afr. Mus., xii, p. 153.
1921. Broom, P.Z.S., p. 659.
Type: skull in British Museum.

Genus CHELYRHYNCHUS, Haughton.

Chelyrhynchus lachrymalis, Haughton.

1917. Haughton, Ann. S. Afr. Mus., xii, p. 156, figs. 37, 38.
Type: skull in South African Museum.

Genus DICYNODON, Owen.

Dicynodon alticeps, Broom and Haughton.

1913. Broom and Haughton, Ann. S. Afr. Mus., xii, p. 37, pl. vii, 1–2.
1917. Haughton, ,, ,, xii, p. 138, fig. 32.
Type: skull in South African Museum.

Dicynodon andrewsi, Broom.

1921. Broom, P.Z.S., p. 650, fig. 30.
1923. ,, ,, p. 680, fig. 13A.
Type: skull in coll. Dr. Broom.

Dicynodon bolorhinus (Broom).

1911. Broom, *Oudenodon bolorhinus*, P.Z.S., p. 1076, pl. lxiii, 10.
Type: an imperfect snout in American Museum of Natural History.

Dicynodon breviceps, Haughton.

1915. Haughton, Ann. S. Afr. Mus., xii, p. 59, pl. xi, 2.
1917. ,, ,, ,, xii, p. 139.
Type: imperfect and weathered skull and lower jaw in South African Museum.

Dicynodon brevirostris (Owen).

1876. Owen, *Oudenodon brevirostris*, Cat. Foss. Rept. S. Afr., p. 57, pls. lviii, lix.
Type: skull in British Museum.

Dicynodon cavifrons, Broom and Haughton.

1917. Broom and Haughton, Ann. S. Afr. Mus., xii, p. 120, fig. 20.
1917. Haughton, ,, ,, xii, p. 140.
Type: skull in South African Museum.

Dicynodon corstorphinei, Broom and Haughton.

1917. Broom and Haughton, Ann. S. Afr. Mus., xii, p. 119, fig. 19.
1917. Haughton, ,, ,, xii, p. 131.
Type: incomplete skull and lower jaw in South African Museum.

Dicynodon curtus, Broom.

1921. Broom, P.Z.S., p. 653, fig. 33.
Type: crushed skull in coll. Dr. Broom.

Dicynodon cyclops, Haughton.

1917. Haughton, Ann. S. Afr. Mus., xii, p. 131, figs. 27–29.
Type: skull in South African Museum.

Dicynodon dubius, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 46, pl. lxix, 1, 2.
Type: mutilated skull in British Museum.

Dicynodon feliceps, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 45, pl. xliii.
1889. Seeley, Phil. Trans., B, 180, pl. x, 3.
1913. Sollas and Sollas, Phil. Trans., B, 204, p. 201, pls. xvii, xviii.
1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 445.
1914. ,, Phil. Trans., B, 206, pl. v, 50, 51.
1915. ,, Bull. Amer. Mus. Nat. Hist., xxv, p. 129.
Type: skull and lower jaw in British Museum.

Dicynodon gracilis (Broom).

1901. Broom, *Oudenodon gracilis*, P.Z.S., p. 162.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 134, fig. 30.
Type: crushed skull in South African Museum.

Dicynodon grandis, Haughton.

1917. Haughton, Ann. S. Afr. Mus., xii, p. 140, pl. xvi.
Type: skull and lower jaw in South African Museum.

Dicynodon halli, Watson.

1914. Watson, Ann. Mag. Nat. Hist., ser. 8, xiv, p. 95, fig. 1.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 142.
Type: skeleton in British Museum.

Dicynodon ictidops, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 446, figs. 5, 6.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 135.
Type: skull in American Museum of Natural History.

Dicynodon ictinops, Broom.

1921. Broom, P.Z.S., p. 656, fig. 35.
Type: skeleton in coll. Dr. Broom.

Dicynodon ingens, Broom.

1907. Broom, Ann. Natal Mus., i, p. 168, pl. xxviii, 1–4.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 142.
Type: palatal portion of a skull in the Natal Museum.

Dicynodon jouberti, Broom.

1905. Broom, Rec. Albany Mus., i, p. 331.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 128, fig. 25.
Type: skull and lower jaw in South African Museum.

Dicynodon kolbei (Broom).

1911. Jaekel, *Udenodon* sp., Die Wirbeltiere, p. 192, figs. 210–212.
1912. Broom, *Oudenodon kolbei*, Ann. S. Afr. Mus., vii, p. 337, figs. 1–5.
1913. ,, *Diictodon kolbei*, Bull. Amer. Mus. Nat. Hist., xxxii, p. 454.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 143, fig. 33.
Type: skull in South African Museum.

Dicynodon lacerticeps, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 30, pl. xxii.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 144.
Type: skull in the British Museum.

Dicynodon leoniceps, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 32, pls. xxiv–xxvi.
1876. ,, *D. pardiceps*, Cat. Foss. Rept. S. Afr., p. 42, pls. xxxviii, xxxix.
1876. ,, *D. rectidens*, ,, ,, ,, p. 44, pl. xl.
1889. Seeley, Phil. Trans., B, 180, p. 220, pl. x, 3, 6.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 146.
Type: skull in the British Museum.

Dicynodon leontops, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 451, fig. 12.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 146.
Type: skull, with vertebrae, in American Museum of Natural History.

Dicynodon lissops, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 450, fig. 11.
Type: somewhat crushed skull in American Museum of Natural History.

Dicynodon lutriceps, Broom.

1912. Broom, P.Z.S., p. 870, pl. xcii, 14–16.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 136.
Type: an imperfect skull in American Museum of Natural History.

Dicynodon macrorhynchus, Broom.

1921. Broom, P.Z.S., p. 756, fig. 36.
Type: skull in coll. Dr. Broom.

Dicynodon magnus (Owen).

1876. Owen, *Oudenodon magnus*, Cat. Foss. Rept. S. Afr., p. 56, pls. liv–lvii.
1880. ,, *Platypodosaurus robustus*, Quart. Journ. Geol. Soc., xxxvi, p. 414, pls. xvi–xvii.
1881. ,, ,, ,, xxxvii, p. 266, pl. x.
Type: skull in British Museum.

Dicynodon megalops (Owen).

1876. Owen, *Oudenodon megalops*, Cat. Foss. Rept. S. Afr., p. 62, pl. lxiii, 4, 5.
Type: a mutilated skull in British Museum.

Dicynodon megalorhinus (Broom).

1904. Broom, *Oudenodon megalorhinus*, Rec. Albany Mus., i, p. 180.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 130, fig. 26.
Type: incomplete skull in South African Museum.

Dicynodon moschops, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 447, figs. 7, 8.
Type: good skull in American Museum of Natural History.

Dicynodon mustoi, Haughton.

1915. Haughton, Ann. S. Afr. Mus., xii, p. 58, pl. xi, 1.
1917. ,, ,, ,, xii, p. 147, fig. 35.
Type: skull and lower jaw in South African Museum.

Dicynodon osborni, Broom.

1921. Broom, P.Z.S., p. 651, fig. 31.
Type: incomplete skull in coll. Dr. Broom.

Dicynodon planus, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 452, figs. 13, 14.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 149.
Type: skull in American Museum of Natural History.

Dicynodon platyceps, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 444, fig. 4.
1915. ,, ,, ,, ,, ,, xxv, p. 135, figs. 26, 27.
Type: a complete skull in American Museum of Natural History.

Dicynodon prognathus (Owen).

1876. Owen, *Oudenodon prognathus*, Cat. Foss. Rept. S. Afr., p. 59, pl. lxi.
Type: orbital and facial part of skull in British Museum.

Dicynodon psittacops, Broom.

1912. Broom, P.Z.S., p. 869, pl. xcii, 17.
1915. ,, Bull. Amer. Mus. Nat. Hist., xxv, p. 139, fig. 28.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 136, fig. 31.
Type: a nearly complete skeleton in American Museum of Natural History.

Dicynodon pygmaeus, Broom and Haughton.

1917. Broom and Haughton, Ann. S. Afr. Mus., xii, p. 123, fig. 23.
1917. Haughton, ,, ,, xii, p. 149.
Type: slightly crushed skull in South African Museum.

Dicynodon recurvidens, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 46, pl. lxix, 3–4.
Type: skull in British Museum.

Dicynodon rogersi, Broom and Haughton.

1917. Broom and Haughton, Ann. S. Afr. Mus., xii, p. 121, figs. 21, 22.
1917. Haughton, „ „ xii, p. 150.
Type: skull and lower jaw in South African Museum.

Dicynodon schwarzi, Broom.

1919. Broom, Rec. Albany Mus., iii, p. 220, pl. vii, and fig. A.
Type: skull in Albany Museum.

Dicynodon sollasi, Broom.

1921. Broom, P.Z.S., p. 648, figs. 28, 29.
1922. von Huene, Palaeont. Zeitschr., v, p. 58, figs. 1–4.
Type: skull in coll. Dr. Broom.

Dicynodon strigiceps, Owen.

1855. Owen, Trans. Geol. Soc., 2nd ser., vii, pl. vi, 2, 3.
1876. „ Cat. Foss. Rept. S. Afr., p. 61, pl. xliv, 4.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 151.
Type: anterior part of skull in British Museum.

Dicynodon testudiceps, Owen.

1845. Owen, Trans. Geol. Soc., vii, p. 71.
1876. „ Cat. Foss. Rept. S. Afr., p. 45, pl. xliv, 1–3.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 151.
Type: anterior two-thirds of skull in British Museum.

Dicynodon testudirostris, Broom and Haughton.

1913. Broom and Haughton, Ann. S. Afr. Mus., xii, p. 36, pl. vii, 3, 4.
1917. Haughton, „ „ xii, p. 151, fig. 36.
Type: skull in South African Museum.

Dicynodon truncatus (Broom).

1899. Broom, *Oudenodon truncatus*, Ann. S. Afr. Mus., i, p. 455, pl. x, 4.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 153.
Type: a very unsatisfactory anterior portion of a skull in the Port Elizabeth Museum.

Dicynodon tylorhinus, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 448, figs. 9, 10.

Type: front half of a somewhat crushed skull in the American Museum of Natural History.

Dicynodon watsoni, Broom.

1921. Broom, P.Z.S., p. 653, fig. 32.

Type: fragmentary skull in coll. Dr. Broom.

Dicynodon whaitsi, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 443, fig. 3.

1917. Haughton, Ann. S. Afr. Mus., xii, p. 154.

Type: anterior portion of skull and mandible in American Museum of Natural History.

Dicynodon woodwardi, Broom.

1921. Broom, P.Z.S., p. 655, fig. 34.

Type: incomplete skull in coll. Dr. Broom.

Genus DIICTODON, Broom.

Diictodon galeops, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 453, fig. 15.

Type: complete skull in American Museum of Natural History.

Genus EOCYCLOPS, Broom.

Eocyclops longus, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 441, figs. 1, 2.

1917. Haughton, Ann. S. Afr. Mus., xii, p. 160, figs. 39, 40, and pl. xvii.

Type: skull in American Museum of Natural History.

Genus EOSIMOPS, Broom.

Eosimops newtoni, Broom.

1921. Broom, P.Z.S., p. 661, fig. 39.

Type: skull in coll. Dr. Broom.

Genus KANNEMEYERIA, Seeley.

Kannemeyeria erithrea, Haughton.

1915. Haughton, Ann. S. Afr. Mus., xii, p. 91, figs. 12–14.

1917. ,, ,, ,, xii, p. 172.

Type: a skull and lower jaw, with vertebral column, in the South African Museum.

Kannemeyeria latifrons (Broom).

1899. Broom, *Dicynodon latifrons*, Ann. S. Afr. Mus., i, p. 452.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 173.
Type: an imperfect and crushed skull in the Port Elizabeth Museum.

Kannemeyeria simocephalus (Weithofer).

1888. Weithofer, *Dicynodon simocephalus*, Ann. Hofmus. Wien, iii, p. 1.
1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 452.
1923. „ P.Z.S., p. 681, fig. 14.
Type: an imperfect skull in Vienna Museum.

Genus LYSTROSAURUS, Cope.

The genus *Lystrosaurus* stands in need of a complete systematic revision; for the sake of convenience, however, all the hitherto-described species are included in the following list. An excellent account of the structure of the lower jaw in an unidentified species is given in 1914, van Hoepen, Ann. Transv. Mus., iv, p. 208, pls. xvi, xvii.

Lystrosaurus alfredi (Owen).

1862. Owen, *Ptychognathus alfredi*, Phil. Trans., p. 456.
1876. „ „ „ Cat. Foss. Rept. S. Afr., p. 51, pl. l.
Type: skull and mandible in British Museum.

Lystrosaurus andersoni, Broom.

1907. Broom, Rept. Geol. Surv. Natal, iii, p. 93.
Type: portion of a skull in the Natal Museum.

Lystrosaurus boopis (Owen).

1876. Owen, *Ptychognathus boopis*, Cat. Foss. Rept. S. Afr., p. 50, pl. xlviii, 1; xlix, 3.
Type: skull and lower jaw, with other bones, in the British Museum.

Lystrosaurus breyeri, van Hoepen.

1916. van Hoepen, Ann. Transv. Mus., v, p. 214.
Type: skull in Transvaal Museum.

Lystrosaurus declivis (Owen).

1876. Owen, *Ptychognathus declivis*, Cat. Foss. Rept. S. Afr., p. 48, pls. xlv, xlvi, 1.
Type: skull in British Museum.

Lystrosaurus depressus (Owen).

1876. Owen, *Ptychognathus depressus*, Cat. Foss. Rept. S. Afr., p. 53, pl. li.

Type: skull in British Museum.

Lystrosaurus frontosus, Cope.

1870. Cope, Proc. Amer. Phil. Soc., xi, p. 419.

Type: partial skull in ?.

Lystrosaurus jorisseni, van Hoepen.

1916. van Hoepen, Ann. Transv. Mus., v, p. 215.

Type: skull in Transvaal Museum.

Lystrosaurus latirostris (Owen).

1860. Owen, *Ptychognathus latirostris*, Quart. Journ. Geol. Soc., p. 49.

1876. ,, ,, ,, Cat. Foss. Rept. S. Afr., p. 49, pls. xlvi, 2; xlvii; xlviii, 2.

1903. Broom, Rec. Albany Mus., i, p. 3.

1912. Watson, ,, ,, ,, ii, p. 287, pls. xv, xvi.

1913. van Hoepen, Ann. Transv. Mus., iv, p. 1.

Type: skull in British Museum.

Lystrosaurus maccaigi (Seeley).

1898. Seeley, *Rhabdocephalus maccaigi*, Ann. Mag. Nat. Hist., vii, p. 165.

1903. Broom, Rec. Albany Mus., i, p. 6, pl. i, 3.

Type: skull in Albany Museum.

Lystrosaurus murrayi (Huxley).

1859. Huxley, *Dicynodon murrayi*, Quart. Journ. Geol. Soc., xv, p. 649, pls. xxii, xxiii.

1890. Lydekker, *Ptychosiagum murrayi*, Cat. Foss. Rept. Amphib., iv, p. 37.

1902. Broom, ,, ,, Trans. S. Afr. Phil. Soc., xi, p. 233, pl. xxxii, 1, 2, 6, 7, 9–12.

Type: skull in British Museum.

Lystrosaurus oviceps, Haughton.

1915. Haughton, Ann. S. Afr. Mus., xii, p. 61, pl. xi, 3, 4.

Type: skull and lower jaw in South African Museum.

Lystrosaurus platyceps (Seeley).

1898. Seeley, *Mochlorhinus platyceps*, Ann. Mag. Nat. Hist., vii, p. 164.
1903. Broom, Rec. Albany Mus., i, p. 7.
Type: skull in Albany Museum.

Lystrosaurus putterilli, van Hoepen.

1915. van Hoepen, Ann. Transv. Mus., v, p. 70, pls. x–xii.
Type: skeletal remains in Transvaal Museum.

Lystrosaurus theileri, van Hoepen.

1916. van Hoepen, Ann. Transv. Mus., v, p. 215.
Type: skull in Transvaal Museum.

Lystrosaurus verticalis (Owen).

1876. Owen, *Ptychognathus verticalis*, Cat. Foss. Rept. S. Afr., p. 50, pl. xlix, 1, 2.
Type: skull in British Museum.

Lystrosaurus wageri, van Hoepen.

1916. van Hoepen, Ann. Transv. Mus., v, p. 216.
Type: skull in Transvaal Museum.

Lystrosaurus wagneri, van Hoepen.

1916. van Hoepen, Ann. Transv. Mus., v, p. 216.
Type: skull in Transvaal Museum.

Genus MYOSAURUS, Haughton.

Myosaurus gracilis, Haughton.

1917. Haughton, Ann. S. Afr. Mus., xii, p. 164, figs. 41, 42.
Co-types: two skulls in South African Museum.

Genus PALEMYDOPS, Broom.

Palemydops platysoma, Broom.

1921. Broom, P.Z.S., p. 665, fig. 40.
Type: skull in coll. Dr. Broom.

Genus PROLYSTROSAURUS, Haughton.

Prolystrosaurus natalensis, Haughton.

1917. Haughton, Ann. S. Afr. Mus., xii, p. 167, figs. 43, 44, and pl. xviii.
Type: skull and lower jaw in South African Museum.

Prolystrosaurus strigops (Broom).

1913. Broom, *Dicynodon strigops*, Rec. Albany Mus., ii, p. 400.
1915. ,, ,, ,, Bull. Amer. Mus. Nat. Hist., xxv, p. 140, fig. 29.
1917. Haughton, Ann. S. Afr. Mus., xii, p. 171.
Type: imperfect skull in American Museum of Natural History.

Family ENDOTHIODONTIDAE.

Genus CHELYOPOSAURUS, Broom.

Chelyoposaurus williamsi, Broom.

1904. Broom, Rec. Albany Mus., i, p. 184.
1904. ,, Trans. S. Afr. Phil. Soc., xv, p. 277, pl. xiii, 31.
Type: an imperfect skeleton in a slab of sandstone in the M'Gregor Memorial Museum, Kimberley.

Genus CRYPTOCYNODON, Seeley.

Cryptocynodon simus, Seeley.

1895. Seeley, Phil. Trans., B, 185, p. 1002, pl. lxxxviii, 4, 5.
1905. Broom, Trans. S. Afr. Phil. Soc., xv, p. 273, pl. xiii, 19.
Type: a weathered anterior half of a skull in British Museum.

Genus DIAELURODON, Broom.

Diaelurodon whaitsi, Broom.

1911. Broom, P.Z.S., p. 1075, pl. lxiii, 6–7.
Type: skull in American Museum of Natural History.

Genus EMYDOPS, Broom.

Emydops arctatus (Owen).

1876. Owen, *Cistecephalus arctatus*, Cat. Foss. Rept. S. Afr., p. 65, pl. lxv, 2–6.
1910. Broom, ,, ,, Trans. Roy. Soc. S. Afr., ii, p. 24.
1913. ,, Bull. Amer. Mus. Nat. Hist., xxxii, p. 454, fig. 18.
Type: an imperfect skull in the British Museum.

Emydops longiceps, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 455, fig. 17.
Type: skull in American Museum of Natural History.

Emydops minor, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 454, fig. 16.
Type: somewhat crushed skull, with mandibles, in American Museum of Natural History.

Emydops parvus, Broom.

1921. Broom, P.Z.S., p. 669, fig. 43.
Type: skull in coll. Dr. Broom.

Genus EMYDOPSIS, Broom.

Emydopsis longus, Broom.

1921. Broom, P.Z.S., p. 667, fig. 42.
Type: skull in coll. Dr. Broom.

Emydopsis platyceps (Broom and Haughton).

1917. Broom and Haughton, *Emydops platyceps*, Ann. S. Afr. Mus., xii, p. 124, fig. 24.
1921. Broom, P.Z.S., p. 668.
Type: skull in South African Museum.

Emydopsis sciuroides, Broom.

1921. Broom, P.Z.S., p. 668, fig. 41, B.
Type: skull in coll. Dr. Broom.

Emydopsis trigoniceps (Broom).

1901. Broom, *Oudenodon gracilis* (pars), P.Z.S., p. 162.
1904. ,, *Oudenodon trigoniceps*, Rec. Albany Mus., i, p. 73, pl. iv, 2.
1917. Haughton, *Dicynodon trigoniceps*, Ann. S. Afr. Mus., xii, p. 138.
1921. Broom, P.Z.S. p. 149, fig. 11.
1921. ,, ,, p. 666, fig. 41, A.
Type: a good skull in the Albany Museum.

Genus EMYDORHYNCHUS, Broom.

Emydorhynchus palustris, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 456, fig. 19.
1914. ,, Phil. Trans., B, 206, pl. v, figs. 52–61.
Type : skull in American Museum of Natural History.

Genus EMYDURANUS, Broom.

Emyduranus platyops, Broom.

1921. Broom, P.Z.S., p. 670, fig. 44.
Type : partial skull in coll. Dr. Broom.

Genus ENDOTHIODON, Owen.

Endothiodon angusticeps, Broom.

1915. Broom, *E. uniseries*, Bull. Amer. Mus. Nat. Hist., xxv, p. 151, fig. 42.
1923. ,, P.Z.S., p. 682, fig. 15.
Type : a skeleton in the American Museum of Natural History.

Endothiodon bathystoma, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 66, pls. lxvi, lxvii.
1879. ,, Quart. Journ. Geol. Soc., xxxv, p. 557.
1905. Broom, Trans. S. Afr. Phil. Soc., xv, p. 261, pls. xii, xiv.
1915. ,, Bull. Amer. Mus. Nat. Hist., xxv, p. 147.
Type : the forepart of skull and lower jaw in British Museum.

Endothiodon crassus, Broom.

1921. Broom, P.Z.S., p. 672, fig. 45.
Type : skull in coll. Dr. Broom.

Endothiodon paucidens, Broom.

1915. Broom, Bull. Amer. Mus. Nat. Hist., xxv, p. 148, fig. 39.
Type : skull in American Museum of Natural History.

Endothiodon platyceps, Broom.

1912. Broom, P.Z.S., p. 867, pl. xciii, 19.
1915. ,, Bull. Amer. Mus. Nat. Hist., xxv, p. 150, fig. 40.
Type : weathered skull and mandibles in American Museum of Natural History.

Endothiodon seeleyi, Broom.

1892. Seeley, *E. bathystoma*, Quart. Journ. Geol. Soc., xlviii, p. 476, figs. 1, 2.
1915. Broom, Bull. Amer. Mus. Nat. Hist., xxv, p. 149.
Type : jaw in the British Museum.

Endothiodon uniseries, Owen.

1879. Owen, Quart. Journ. Geol. Soc., xxxv, p. 557.
1895. Seeley, *Esoterodon uniseries*, Phil. Trans., B, 185, p. 102.
1905. Broom, „ „ Trans. S. Afr. Phil. Soc., xv, p. 271, pl. xiii, 15–18.
1915. „ Bull. Amer. Mus. Nat. Hist., xxv, p. 151, fig. 41.
Type : a snout in the British Museum.

Endothiodon whaitsi, Broom.

1912. Broom, P.Z.S., p. 866, pl. xciii, 18.
1915. „ Bull. Amer. Mus. Nat. Hist., xxv, p. 154, fig. 43.
Type : skull and mandibles in American Museum of Natural History.

Genus PRISTERODON, Huxley.

Pristerodon agilis (Broom).

1904. Broom, *Opisthoctenodon agilis*, Rec. Albany Mus., i, p. 71, p. iv, 1.
1905. „ „ „ Trans. S. Afr. Phil. Soc., xv, p. 275, pl. xiii, 25–30.
1915. „ P.Z.S., p. 358.
Type : skull, part of shoulder girdle and fore-limb in Albany Museum.

Pristerodon brachyops (Broom).

1905. Broom, *Opisthoctenodon brachyops*, Trans. S. Afr. Phil. Soc., xv, p. 276, pl. xiii, 23–24.
1915. „ P.Z.S., p. 358.
Type : a weathered skull in the South African Museum.

Pristerodon mackayi, Huxley.

1868. Huxley, Geol. Mag., p. 201, pl. xii.
1898. Seeley, *Oudenodon pithecops*, Geol. Mag., p. 107.
1905. Broom, Trans. S. Afr. Phil. Soc., xv, p. 277, pl. xiii, 32.
1913. „ Bull. Amer. Mus. Nat. Hist., xxxii, p. 456.
1915. „ P.Z.S., p. 355, fig. 1.
Type : an imperfect skull in the British Museum.

Pristerodon raniceps (Owen).

1876. Owen, *Oudenodon raniceps*, Cat. Foss. Rept. S. Afr., p. 61.
1915. Broom, P.Z.S., p. 357, fig. 2.
Type: a much crushed skull, with lower jaws, in the British Museum.

Genus PRODICYNODON, Broom.

Prodicynodon beaufortensis, Broom.

1912. Broom, P.Z.S., p. 867, pl. xciii, 21.
Type: the front half of a much crushed skull in the American Museum of Natural History.

Prodicynodon pearstonensis, Broom.

1904. Broom, Rec. Albany Mus., i, p. 70, pl. iv, 3, 4.
1905. ,, Trans. S. Afr. Phil. Soc., xv, p. 274, pl. xiii, 22.
Type: an imperfect anterior half of skull in Albany Museum.

Genus TAOGNATHUS, Broom.

Taognathus megalodon, Broom.

1911. Broom, P.Z.S., p. 1076, pl. lxii, 2–4.
Type: imperfect part of skull, with mandibles, in American Museum of Natural History.

Genus TROPIDOSTOMA, Seeley.

Tropidostoma microtrema (Seeley).

1889. Seeley, *Dicynodon microtrema*, Phil. Trans., B, 180, p. 228, pl. xi.
1889. ,, *Tropidostoma dunni*, loc. cit., p. 232, pl. xii.
1915. Broom, P.Z.S., p. 358, figs. 3, 4.
Type: an occiput in the British Museum.

ORDER THERIODONTIA, Owen.

Sub-Order THEROCEPHALIA, Broom.

Family ALOPECOPSIDAE, nov.

Genus ALOPECOPSIS, Broom.

Alopecopsis atavus, Broom.

1920. Broom, P.Z.S., p. 347, figs. 4, 5, 6.
Type: skull and lower jaw in coll. Dr. Broom.

Family Ictidosuchidae, Broom.

Genus arnognathus, Broom.

Arnognathus parvidens, Broom.

1907. Broom, Trans. S. Afr. Phil. Soc., xviii, p. 38, pl. iii, 6.

Type: a dentary in the South African Museum. As the species is known only from a single dentary, its assignation to this family is a tentative one.

Genus cerdodon, Broom.

Cerdodon tenuidens, Broom.

1915. Broom, P.Z.S., p. 166, fig. 3.

Type: crushed and imperfect skull in nodule in the British Museum.

Genus ictidosuchus, Broom.

Ictidosuchus longiceps, Broom.

1920. Broom, P.Z.S., p. 343, figs. 1–3.

Type: skull in coll. Dr. Broom.

Ictidosuchus primaevus, Broom.

1900. Broom, Ann. Mag. Nat. Hist., ser. 7, vi, p. 314.
1901. „ Trans. S. Afr. Phil. Soc., xi, p. 177, pls. xxvi, xxvii, 1–9.
1912. „ Anatom. Anzeiger, xli, p. 628, fig. 2.
1915. „ Bull. Amer. Mus. Nat. Hist., xxv, p. 119.

Type: portion of skeleton in American Museum of Natural History.

Family Pristerognathidae.

Genus alopecodon, Broom.

Alopecodon priscus, Broom.

1908. Broom, Ann. S. Afr. Mus., iv, p. 361, pl. xlvi, 2.

Type: skull in South African Museum.

Alopecodon rugosus, Broom.

1908. Broom, Ann. S. Afr. Mus., iv, p. 363.

Type: a very bad skull-fragment in South African Museum.

Genus alopecognathus, Broom.

Alopecognathus angusticeps, Broom.

1915. Broom, Bull. Amer. Mus. Nat. Hist., xxv, p. 116, fig. 6.

Type: a skull, with mandibles, in American Museum of Natural History.

Alopecognathus minor, Haughton.

1918. Haughton, Ann. S. Afr. Mus., xii, p. 180, figs. 46, 47, 58, *a*, *b*.
Type: skull in South African Museum.

Genus ALOPECORHINUS, Broom.

Alopecorhinus parvidens, Broom.

1912. Broom, P.Z.S., p. 864, pl. xci, 9.
Type: the imperfect front portion of a skull in the American Museum of Natural History.

Genus BROOMISAURUS, Joleaud.

Broomisaurus planiceps (Broom).

1913. Broom, *Scymnorhinus planiceps*, Rec. Albany Mus., ii, p. 399.
1920. Joleaud, Rev. critique de Paleozool., xxiv, p. 36.
Type: an imperfect snout in the Albany Museum, Grahamstown.

Genus GLANOSUCHUS, Broom.

Glanosuchus macrops, Broom.

1904. Broom, Trans. S. Afr. Phil. Soc., xv, p. 85, pl. vi, 1–6.
Type: a fairly complete skull, displaying imperfect sutures, in the South African Museum.

Genus HYAENASUCHUS, Broom.

Hyaenasuchus whaitsi, Broom.

1908. Broom, Ann. S. Afr. Mus., iv, p. 364, pl. xlvi, 1.
Type: skull and lower jaw in South African Museum.

Genus ICTIDOSAURUS, Broom.

Ictidosaurus angusticeps, Broom.

1903. Broom, Ann. S. Afr. Mus., iv, p. 151, pl. xvii, 4.
1915. ,, Bull. Amer. Mus. Nat. Hist., xxv, p. 118.
Type: imperfect snout, with lower jaw, in South African Museum.

Genus LYCOSUCHUS, Broom.

Lycosuchus mackayi, Broom.

1903. Broom, Ann. S. Afr. Mus., iv, p. 154.
Type: a very imperfect skull in South African Museum.

Lycosuchus vanderrieti, Broom.

1902. Broom, Trans. S. Afr. Phil. Soc., xiv, p. 197, pls. i, ii.
1910. ,, Bull. Amer. Mus. Nat. Hist., xxviii, p. 208.
Type: a perfect skull and lower jaw in the University of Stellenbosch.

Genus MOSCHORHINUS, Broom.

Moschorhinus kitchingi, Broom.

1920. Broom, P.Z.S., p. 351, figs. 7, 8.
This is a very late member of the family. Type: anterior two-thirds of a skull in coll. Dr. Broom.

Genus PARDOSUCHUS, Broom.

Pardosuchus whaitsi, Broom.

1908. Broom, Ann. S. Afr. Mus., iv, p. 367.
Type: front half of a skull in South African Museum.

Genus PRISTEROGNATHUS, Seeley.

Pristerognathus baini, Broom.

1904. Broom, Trans. S. Afr. Phil. Soc., xv, p. 87, pl. vi, 7, 8.
Type: an imperfect snout in the South African Museum. No molar teeth are seen, and the species is probably unidentifiable.

Pristerognathus polyodon, Seeley.

1895. Seeley, Phil. Trans., B, 185, p. 994, pl. lxxxviii, 3.
Type: weathered snout in British Museum.

Pristerognathus platyrhinus, Broom.

1912. Broom, P.Z.S., p. 863, pl. xci, 8.
1914. ,, Phil. Trans., B, 206, p. 47, pl. vi, 73.
Type: part of front half of skull, with mandibles, in American Museum of Natural History.

Genus SCYLACOIDES, Broom.

Scylacoides ferox, Broom.

1915. Broom, Bull. Amer. Mus. Nat. Hist., xxv, p. 119, fig. 7.
Type: preorbital portion of a very crushed skull in American Museum of Natural History.

Genus SCYLACORHINUS, Broom.

Scylacorhinus falkenbachi, Broom.

1915. Broom, Bull. Amer. Mus. Nat. Hist., xxv, p. 120, fig. 8.
Type: an imperfect skull in American Museum of Natural History.

Genus SCYLACOSAURUS, Broom.

Scylacosaurus sclateri, Broom.

1903. Broom, Ann. S. Afr. Mus., iv, p. 147, pl. xvii.
1910. ,, Bull. Amer. Mus. Nat. Hist., xxviii, p. 207.
1914. ,, Phil. Trans., B, 206, p. 43, pl. iv, 43.
Type: anterior two-thirds of skull in South African Museum.

Genus SCYMNOSAURUS, Broom.

Scymnosaurus ferox, Broom.

1903. Broom, Ann. S. Afr. Mus., iv, p. 152.
Type: an imperfect snout, with dentaries, in South African Museum.

Scymnosaurus warreni, Broom.

1907. Broom, Ann. Natal Mus., i, p. 169, pl. xxviii, 5–7.
Type: crushed snout and dentary in the Natal Museum. The assignation of the species to *Scymnosaurus* is doubtful.

Scymnosaurus watsoni, Broom.

1914. Watson, *Lycosuchus* sp., P.Z.S., p. 1035, fig. 7.
1915. Broom, P.Z.S., p. 169, fig. 6.
1921. Watson, ,, p. 80, figs. 23–24.
Type: a skull in the British Museum.

Genus TROCHOSAURUS, Haughton.

Trochosaurus intermedius, Haughton.

1915. Haughton, Ann. S. Afr. Mus., xii, p. 55.
Type: weathered and crushed skull and lower jaw in the South African Museum.

Genus TROCHOSUCHUS, Broom.

Trochosuchus acutus, Broom.

1908. Broom, Ann. S. Afr. Mus., iv, p. 366.
Type: preorbital portion of a skull in South African Museum.

Trochosuchus major, Broom.

1915. Broom, Bull. Amer. Mus. Nat. Hist., xxv, p. 121, fig. 9.

Type: a weathered imperfect skull in the American Museum of Natural History.

Family SCALOPOSAURIDAE.

Genus AKIDNOGNATHUS, Haughton.

Akidnognathus parvus, Haughton.

1918. Haughton, Ann. S. Afr. Mus., xii, p. 192.

Type: skull in South African Museum.

Genus ICTICEPHALUS, Broom.

Icticephalus polycynodon, Broom.

1915. Broom, P.Z.S., p. 164, fig. 2.

Type: the front half of a weathered skull in the South African Museum.

Genus ICTIDOGNATHUS, Broom.

Ictidognathus hemburyi, Broom.

1912. Broom, P.Z.S., p. 865, pl. xci, 10, 11.
1914. ,, Phil. Trans., B, 206, p. 47, pl. vi, 76.
1915. ,, Bull. Amer. Mus. Nat. Hist., xxv, p. 117.

Type: skull lacking back part, with mandibles, in American Museum of Natural History. Possibly belongs to a new genus.

Ictidognathus parvidens, Broom.

1911. Broom, P.Z.S., p. 1078.
1914. ,, Phil. Trans., B, 206, p. 47, pl. vi, 75.

Type: anterior half of skull, with mandibles, in American Museum of Natural History.

Genus SCALOPOSAURUS, Owen.

Scaloposaurus constrictus, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 24, pl. xvi, 10–13.
1910. Broom, Bull. Amer. Mus. Nat. Hist., xxviii, p. 209.
1914. ,, Phil. Trans., B, 206, p. 17, pl. iv, 41, 42.

Type: a skull in the British Museum.

Genus SIMORHINELLA, Broom.

Simorhinella baini, Broom.

1915. Broom, P.Z.S., p. 163, fig. 1.

Type: a much weathered anterior half of a skull in the British Museum.

Family Whaitsidae, Haughton.

Genus whaitsia, Haughton.

Whaitsia platyceps, Haughton.

1918. Haughton, Ann. S. Afr. Mus., xii, p. 184, figs. 48–50.
1920. Broom, P.Z.S., p. 354, fig. 9.
Type : skull in the South African Museum.

Sub-Order Gorgonopsia, Seeley.

Genus aelurognathus, Haughton.

Aelurognathus serratidens (Haughton).

1915. Haughton, *Scymnognathus serratidens*, Ann. S. Afr. Mus., xii, p. 88, fig. 11, and pl. xiii, 2–4.
1924. ,, Ann. S. Afr. Mus., xii, p. 504, fig. 3.
Type : partial skull and lower jaw in the South African Museum.

Aelurognathus tigriceps (Broom and Haughton).

1913. Broom and Haughton, *Scymnognathus tigriceps*, Ann. S. Afr. Mus., xii, p. 26, pl. vi, 1–4.
1913. Broom, *Scymnognathus tigriceps*, Anat. Anzeiger, xliii, p. 230, fig. 1.
1913. ,, ,, ,, P.Z.S., p. 225.
1914. ,, ,, ,, Phil. Trans., B, 206, p. 46, pl. vi, 66.
1918. Haughton, ,, ,, ? Ann. S. Afr. Mus., xii, p. 205, figs. 55 *a*, *b*.
1924. ,, Ann. S. Afr. Mus., xii, p. 503.
Type : skull and forepart of skeleton in South African Museum.

Genus aelurosaurus, Owen.

Aelurosaurus felinus, Owen.

1881. Owen, Quart. Journ. Geol. Soc., xxxvii, p. 26, pl. ix.
1890. Lydekker, Cat. Foss. Rept. Amphib., iv, p. 75, fig. 16.
1895. Seeley, Phil. Trans., B, 185, p. 992, fig. 2, and pl. lxxxviii, 2.
1910. Broom, Trans. Roy. Soc. S. Afr., ii, p. 23.
1921. Watson, P.Z.S., p. 86.
Type : a good skull in the British Museum.

Aelurosaurus striatidens, Broom.

1912. Broom, P.Z.S., p. 863, pl. xci, fig. 7.

Type: an imperfect snout in the American Museum of Natural History.

Aelurosaurus tenuirostris, Broom.

1911. Broom, P.Z.S., p. 1077, pl. lxiii, 9.

Type: most of preorbital portion of skull in American Museum of Natural History.

Aelurosaurus whaitsi, Broom.

1911. Broom, P.Z.S., p. 1077.

Type: part of mandibles and fragments of snout in American Museum of Natural History.

Genus ALOPOSAURUS, Broom.

Aloposaurus gracilis, Broom.

1910. Broom, Bull. Amer. Mus. Nat. Hist., xxviii, p. 208.

1915. „ „ „ xxv, p. 124.

Type: skull, with mandibles, in the American Museum of Natural History.

Genus ARCTOGNATHUS, Broom.

Arctognathus curvimola (Owen).

1876. Owen, *Lycosaurus curvimola*, Cat. Foss. Rept. S. Afr., p. 71, pl. lxviii.

1890. Lydekker, *Aelurosaurus curvimola*, Cat. Foss. Rept. Amphib., iv, p. 77.

1894. Seeley, *Lycosaurus curvimola*, Phil. Trans., B, 185, p. 993, pl. lxxxviii, 1.

1911. Broom, P.Z.S., p. 1079.

1913. Watson, Ann. Mag. Nat. Hist., ser. 8, xi, p. 77, figs. 6, 7.

1921. „ P.Z.S., p. 60, figs. 18, 19.

Type: a skull in the British Museum.

Arctognathus whaitsi, Haughton.

1924. Haughton, Ann. S. Afr. Mus., xii, p. 507, fig. 5.

Type: somewhat weathered skull in South African Museum.

Genus ARCTOPS, Watson.

Arctops willistoni, Watson.

1914. Watson, P.Z.S., p. 1026, figs. 3*c*, 4*b*.
1921. ,, ,, p. 36, figs. 1–3.
Type: skull in the British Museum.

Genus ARCTOSUCHUS, Broom.

Arctosuchus tigrinus (Owen).

1876. Owen, *Lycosaurus tigrinus*, Cat. Foss. Rept. S. Afr., p. 17, pl. xv.
1910. Broom, Trans. Roy. Soc. S. Afr., ii, p. 24.
1911. ,, P.Z.S., p. 1079.
Type: a badly preserved skull in the British Museum. Watson is of the opinion that Broom used a snout of *Scymnognathus whaitsi* when founding the genus *Arctosuchus* for *L. tigrinus*.

Genus ASTHENOGNATHUS, Broom.

Asthenognathus paucidens, Broom.

1915. Broom, Bull. Amer. Mus. Nat. Hist., xxv, p. 125, fig. 11.
Type: a mandible in the American Museum of Natural History.

Genus CERDOGNATHUS, Broom.

Cerdognathus greyi, Broom.

1915. Broom, P.Z.S., p. 168, fig. 5.
Type: an imperfect lower jaw in the British Museum.

Genus CYNOCHAMPSA, Owen.

Cynochampsa laniaria, Owen.

1860. Owen, Quart. Journ. Geol. Soc., xvi, p. 61, pl. iii, 1–4.
1876. ,, Cat. Foss. Rept. S. Afr., p. 20, pls. xviii, xix.
Type: the anterior end of a snout, which may be considered as indeterminable. In British Museum.

Genus CYNODRACO, Owen.

Cynodraco serridens, Owen.

1876. Owen, Quart. Journ. Geol. Soc., xxxii, p. 95, pl. xi, 1–9.
1876. ,, Cat. Foss. Rept. S. Afr., p. 18, pls. xvii–xix.
Type: fore-end of skull in British Museum.

Genus ERIPHOSTOMA, Broom.

Eriphostoma microdon, Broom.

1911. Broom, P.Z.S., p. 1078, pl. lxiii, 12.
1915. ,, Bull. Amer. Mus. Nat. Hist., xxv, p. 117.
Type: an imperfect weathered skull in the American Museum of Natural History.

Genus GALESUCHUS, Haughton.

Galesuchus gracilis, Haughton.

1915. Haughton, Ann. S. Afr. Mus., xii, p. 82, figs. 10, 11*a*.
1924. ,, ,, ,, xii, p. 499, fig. 1.
Type: incomplete weathered skull and lower jaw in South African Museum.

Genus GORGONOGNATHUS, Haughton.

Gorgonognathus longifrons, Haughton.

1915. Haughton, Ann. S. Afr. Mus., xii, p. 84, pl. xiii, 1–3.
1918. ,, ,, ,, xii, p. 209, figs. 56, 57.
1921. Watson, P.Z.S., p. 78.
1924. Haughton, Ann. S. Afr. Mus., xii, p. 505, fig. 4.
Type: partly weathered skull in South African Museum.

Genus GORGONOPS, Owen.

Gorgonops torvus, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 27, pls. xxi, xxii.
1914. Watson, P.Z.S., p. 1031.
1921. ,, ,, p. 39, figs. 4–6.
Type: a skull in the British Museum.

Genus ICTIDORHINUS, Broom.

Ictidorhinus martinsi, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 560, fig. 4.
1914. ,, Phil. Trans., B, 206, p. 46, pl. vi, fig. 67.
Type: crushed skull in American Museum of Natural History.

Genus LEPTOTRACHELUS, Watson.

Leptotrachelus eupachygnathus, Watson.

1912. Watson, *Scymnognathus whaitsi*, Ann. Mag. Nat. Hist., ser. 8, x, p. 578, fig. 3.
1914. ,, ,, ,, P.Z.S., p. 1027, figs. 3–5.
1921. ,, P.Z.S., p. 55, figs. 14–16.
Type: skull and lower jaw in British Museum.

Genus LYCOSAURUS, Owen.

Lycosaurus pardalis, Owen.

1876. Owen, Quart. Journ. Geol. Soc., xxxii, p. 358, figs. 6, 7.
1876. ,, Cat. Foss. Rept. S. Afr., p. 15, pl. xiv.
1911. Broom, P.Z.S., p. 1079.
1921. Watson, ,, p. 58, fig. 17.
Type: a badly preserved skull in the British Museum.

Genus SCYLACOGNATHUS, Broom.

Scylacognathus parvus, Broom.

1913. Broom, Rec. Albany Mus., ii, p. 398.
1914. ,, Phil. Trans., B, 206, p. 46, pl. vi, fig. 65.
Type: skull in Albany Museum.

Genus SCYLACOPS, Broom.

Scylacops capensis, Broom.

1913. Broom, Ann. S. Afr. Mus., xii, p. 8, pl. vi, 5.
1913. ,, P.Z.S., p. 226, pl. xxxvi.
1924. Haughton, Ann. S. Afr. Mus., xii, p. 501, fig. 2.
Type: skull and lower jaw in South African Museum.

Genus SCYMNOGNATHUS, Broom.

Scymnognathus angusticeps, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 558, fig. 2.
1915. ,, ,, ,, ,, xxv, p. 127.
Type: skull, with lower jaw, in American Museum of Natural History.

Scymnognathus minor, Broom.

1913. Broom, Bull. Amer. Mus. Nat. Hist., xxxii, p. 559, fig. 3.
Type: crushed and weathered skull and partial skeleton in American Museum of Natural History.

Scymnognathus parvus, Broom.

1915. Broom, P.Z.S., p. 171, fig. 7.
Type: a nearly complete skull, with mandibles, in the British Museum.

Scymnognathus whaitsi, Broom.

1912. Broom, P.Z.S., p. 861, pl. xc, 4, 5.
1921. „ „ p. 44, figs. 7–13.
Type: skull, with part of mandible, in American Museum of Natural History.

Genus SYCOSAURUS, Haughton.

Sycosaurus laticeps, Haughton.

1924. Haughton, Ann. S. Afr. Mus., xii, p. 509, fig. 6.
Type: skull and lower jaw in South African Museum.

Genus TIGRISUCHUS, Owen.

Tigrisuchus simus, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 17, pl. xvi, 6–9.
Type: snout in British Museum.

Sub-Order BURNETIAMORPHA, Broom.

Genus BURNETIA, Broom.

Burnetia mirabilis, Broom.

1923. Broom, P.Z.S., p. 671, figs. 9–10.
Type: skull in coll. Dr. Broom.

Sub-Order BAURIAMORPHA, Watson.

Genus AELUROSUCHUS, Broom.

Aelurosuchus browni, Broom.

1906. Broom, Trans. S. Afr. Phil. Soc., xvi, p. 376, pl. x.
1922. Haughton, Trans. Roy. Soc. S. Afr., x, p. 305, pl. xiii, 9.
Type: partial skeleton in South African Museum.

Genus BAURIA, Broom.

Bauria cynops, Broom.

1909. Broom, Ann. S. Afr. Mus., vii, p. 272, fig. 1.
1911. „ P.Z.S., p. 895, figs. 168, 169, and pl. xlvi, 6–8.
1914. „ Phil. Trans., B, 206, p. 43, pl. iv, 44, pl. vi, 68.

1914. Watson, P.Z.S., p. 1021, fig. 1.
Type: a good skull in South African Museum.

Genus MELINODON, Broom.

Melinodon simus, Broom.

1905. Broom, Rec. Albany Mus., i, p. 273.
1911. ,, P.Z.S., p. 913, pl. xlvi, 3.
Type: an imperfect skull in South African Museum.

Genus MICROGOMPHODON, Seeley.

Microgomphodon oligocynus, Seeley.

1895. Seeley, Phil. Trans., B, 186, p. 31, pl. i, 1–4.
1914. Watson, P.Z.S., p. 1023, fig. 2.
1914. Broom, Phil. Trans., B, 206, p. 19.
Type: skull in British Museum.

Genus SESAMODON, Broom.

Sesamodon browni, Broom.

1905. Broom, Rec. Albany Mus., i, p. 272.
1911. ,, P.Z.S., p. 913, figs. 179, 180, and pl. xlvi, 4, 5.
1914. ,, Phil. Trans., B, 206, p. 47, pl. vi, 71–72.
1914. Watson, P.Z.S., p. 1025.
1915. Broom, Bull. Amer. Mus. Nat. Hist., xxv, p. 159, fig. 47.
1920. Gregory, Journ. Dental Research, ii, p. 104.
Type: a good skull in South African Museum.

Sub-Order CYNODONTIA, Owen.

Family CYNOGNATHIDAE.

Genus CYNIDIOGNATHUS, Haughton.

Cynidiognathus broomi, Haughton.

1911. Broom, *Cynognathus berryi*, P.Z.S., pl. xlvi, 1–2.
1922. Haughton, Trans. Roy. Soc. S. Afr., xi, p. 305, pl. xiii, 7–8.
Type: partial skull in South African Museum.

Cynidiognathus longiceps, Haughton.

1922. Haughton, Trans. Roy. Soc. S. Afr., xi, p. 299, pl. xiii, 1–6.
Type: skull in South African Museum.

Genus CYNOGNATHUS, Seeley.

Cynognathus berryi, Seeley.

1895. Seeley, Phil. Trans., B, 186, p. 121, figs. 24, 25.
Type: preorbital portion of skull in British Museum.

Cynognathus crateronotus, Seeley.

1895. Seeley, Phil. Trans., B, 186, p. 60, figs. 1–23.
1908. „ Geol. Mag., p. 487, pl. xxiv.
1909. Broom, Ann. S. Afr. Mus., vii, p. 283.
1911. „ P.Z.S., p. 900, figs. 171, 172, and pl. xlvi, 1–2.
1911. Watson, Ann. Mag. Nat. Hist., p. 316.
1914. Broom, Phil. Trans., B, 206, p. 20.
1918. Gregory and Camp, Bull. Amer. Mus. Nat. Hist., xxxviii, p. 538 and figs.
1919. Petronievics, P.Z.S., p. 197, figs. 5–7.
1920. Watson, Ann. Mag. Hist., ser. ix, 6, p. 517, fig. 9.
Type: skull and skeleton in the British Museum.

Cynognathus platyceps, Seeley.

1895. Seeley, Phil. Trans., B, 186, p. 132, figs. 28–30.
1904. Broom, Rec. Albany Mus., i, p. 82.
Type: an almost perfect skull in Albany Museum.

Genus LYCOCHAMPSA, Broom.

Lycochampsa ferox (Broom).

1913. Broom, *Lycognathus ferox*, Bull. Amer. Mus. Nat. Hist., xxxii, p. 557, fig. 1.
1914. „ „ „ Phil. Trans., B, 206, p. 46, pl. vi, 63–64.
1915. „ Bull. Amer. Mus. Nat. Hist., xxv, p. 159.
Type: weathered skull, with mandibles, in American Museum of Natural History.

Family CYNOSUCHIDAE.

Genus CYNISCODON, Broom.

Cyniscodon lydekkeri, Broom.

1890. Lydekker, *Cynosuchus suppostus*, Cat. Foss. Rept. Amphib., iv, p. 72.
1915. Broom, P.Z.S., p. 167, fig. 4.
Type: an imperfect right dentary in the British Museum.

Genus CYNOSUCHUS, Owen.

Cynosuchus suppostus, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 21, pl. xvi, figs. 1–5.
1890. Lydekker, Cat. Foss. Rept. Amphib., iv, p. 71, fig. 15.
1915. Broom, P.Z.S., p. 168.
1920. Watson, Ann. Mag. Nat. Hist., ser. 9, vi, p. 511, fig. 4.
Type: an imperfect skull in the British Museum.

Cynosuchus whaitsi, Haughton.

1918. Haughton, Ann. S. Afr. Mus., xii, p. 197, fig. 53.
Type: somewhat crushed skull in South African Museum.

Family DIADEMODONTIDAE.

Genus CYCLOGOMPHODON, Broom.

Cyclogomphodon platyrhinus (Broom).

1905. Broom, *Diademodon mastacus*, P.Z.S., p. 96.
1913. ,, *Diademodon platyrhinus*, Bull. Amer. Mus. Nat. Hist., xxxii, p. 467, fig. 1.
1919. ,, Rec. Albany Mus., iii, p. 239.
Type: portion of skull, with mandibles, in American Museum of Natural History.

Genus DIADEMODON, Seeley.

Diademodon tetragonus, Seeley.

1894. Seeley, Phil. Trans., B, 185, p. 1030, pl. lxxxix, 1–10.
1919. Broom, Rec. Albany Mus., iii, p. 224.
Type: an imperfect upper jaw, with a few good molars, in the South African Museum. As the complete dental series is unknown, the species is an unsatisfactory one.

Genus GOMPHOGNATHUS, Seeley.

Gomphognathus browni (Seeley).

1894. Seeley, *Diademodon browni*, Phil. Trans., B, 185, p. 1037, pl. lxxxix, 13, 14.
1908. ,, *Diademodon entomophonus*, P.Z.S., p. 611, fig. 130.
1911. Broom, *Gomphognathus minor*, P.Z.S., p. 908, figs. 175–178.
1911. Watson, *Diademodon browni*, Ann. Mag. Nat. Hist., ser. 8, viii, p. 293, figs. 1–6.

1913. Watson, *D. entomophonus*, Ann. Mag. Nat. Hist., ser. 8, xii, p. 218, figs. 1, 3–5.
1913. „ *D. browni*, and *D. entomophonus*, Geol. Mag., p. 147, fig. 3.
1914. Broom, *D. minor*, Phil. Trans., B, 206, pl. iv, 45.
1919. „ Rec. Albany Mus., iii, p. 227.
1919. Watson, *D. browni*, P.Z.S., p. 298, fig. 15, E.

Type of *D. browni*: an incomplete skull in British Museum.
Type of *D. entomophonus*: a skull in British Museum.
Type of *G. minor*: a good skull in British Museum.

Gomphognathus mastacus (Seeley).

1894. Seeley, *Diademodon mastacus*, Phil. Trans., B, 185, p. 1035, pl. lxxxix, 11–12.
1895. „ *Gomphognathus kannemeyeri*, Phil. Trans., B, 186, p. 4, figs. 1, 2.
1895. „ *Gomphognathus polyphagus*, Phil. Trans., B, 186, p. 11, figs. 6–11.
1897. Broom, *G. kannemeyeri*, Journ. Anat. Phys., xxxi, p. 277.
1903. „ „ P.Z.S., p. 177, pl. xviii, 1–2.
1904. „ „ Rec. Albany Mus., i, p. 85.
1911. „ „ P.Z.S., p. 908.
1911. Watson, *Diademodon polyphagus*, Ann. Mag. Nat. Hist., p. 312, fig. 8.
1913. „ *Diademodon mastacus*, Geol. Mag., p. 147, fig. 3.
1919. Broom, Rec. Albany Mus., iii, p. 229.

Type of *D. mastacus*: portion of left maxilla, with teeth, in South African Museum.

Type of *G. kannemeyeri*: back half of skull, entire mandible, and four cervical vertebrae in Albany Museum.

Type of *G. polyphagus*: skull in British Museum.

Genus OCTAGOMPHUS, Broom.

Octagomphus woodi, Broom.

1919. Broom, Rec. Albany Mus., iii, p. 229, fig. 1, and pl. viii, 1–3.

Type: imperfect skull and lower jaw in Albany Museum.

Genus PROTACMON, Watson.

Protacmon brachyrhinus, Watson.

1920. Watson, Ann. Mag. Nat. Hist., ser. 9, vi, p. 518, figs. 10–13.

Type: skull in British Museum.

Genus TRIRACHODON, Seeley.

Trirachodon berryi, Seeley.

1895. Seeley, Phil. Trans., B, 185, pl. lxxxix, 16.
1895. ,, ,, ,, B, 186, p. 53, pl. ii, 9.
Type: anterior part of skull in British Museum.

Trirachodon browni, Broom.

1915. Broom, P.Z.S., p. 172, fig. 8.
Type: the anterior two-thirds of a skull and lower jaw in the British Museum.

Trirachodon kannemeyeri, Seeley.

1895. Seeley, Phil. Trans., B, 186, p. 48, pl. ii, 1–8.
1903. Broom, P.Z.S., p. 177, pl. xviii, 3–5.
1904. ,, Rec. Albany Mus., i, p. 86.
1911. ,, P.Z.S., p. 905, figs. 173, 174.
Type: an almost perfect skull in Albany Museum.

Trirachodon minor, Broom.

1905. Broom, Rec. Albany Mus., i, p. 271.
Type: a crushed and weathered front portion of skull in the South African Museum.

Family GALESAURIDAE.

Genus GALESAURUS, Owen.

Galesaurus planiceps, Owen.

1859. Owen, Quart. Journ. Geol. Soc., xvi, p. 58.
1861. ,, Palaeontology, 2nd ed., p. 268.
1876. ,, Cat. Foss. Rept. S. Afr., p. 23, pl. xix, figs. 6–11.
1889. Seeley, Phil. Trans., B, 180, p. 277, pl. ix, 3–6.
1890. Lydekker, Cat. Foss. Rept. Amphib., iv, p. 68, fig. 14.
1895. Seeley, Phil. Trans., B, 185, p. 989.
1910. Broom, Trans. Roy. Soc. S. Afr., ii, p. 19.
1920. Watson, Ann. Mag. Nat. Hist., ser. 9, vi, p. 507, figs. 1–3
Type: a somewhat crushed skull in British Museum.

Genus GLOCHINODON, van Hoepen.

Glochinodon detinens, van Hoepen.

1916. van Hoepen, Ann. Transv. Mus., v, 3, Suppl. 2.
Type : skull in Transvaal Museum.

Genus ICTIDOPSIS, Broom.

Ictidopsis elegans, Broom.

1912. Broom, P.Z.S., p. 872, pl. xciii, fig. 22.
1916. van Hoepen, *I. formosa*, Ann. Transv. Mus., v, 3, Suppl. 2.
1920. Haughton, ,, Ann. Durban Mus., ii, p. 243, figs. 1–2.
1920. Gregory, Journ. Dental Research, ii, p. 103, fig. 9.
1920. ,, Bull. Amer. Mus. Nat. Hist., xlii, p. 133, fig. 57.
Type : skull in American Museum of Natural History.

Genus NYTHOSAURUS, Owen.

Nythosaurus browni, Broom.

1912. Broom, P.Z.S., p. 874, pl. xciii, 23.
Type : partial dentary in South African Museum.

Nythosaurus larvatus, Owen.

1876. Owen, Cat. Foss. Rept. S. Afr., p. 24, pl. xx, 1–3, pl. xxxiv.
1889. Seeley, *Galesaurus planiceps*, Phil. Trans., B, 180.
1894. ,, *Thrinaxodon liorhinus*, Phil. Trans., B, 185, p. 990.
1911. Broom, P.Z.S., p. 898.
1914. ,, Phil. Trans., B, 206, p. 19.
1920. Watson, *Thrinaxodon liorhinus*, Ann. Mag. Nat. Hist., ser. 9, vi, p. 512, figs. 5–8.
Type : an imperfect skull in British Museum.

Genus PLATYCRANIELLUS, van Hoepen.

Platycraniellus elegans (van Hoepen).

1916. van Hoepen, *Platycranion elegans*, Ann. Transv. Mus., v, 3, Suppl. 2, p. 2.
1917. ,, Ann. Transv. Mus., v, 4, p. 217.
Type : skull in Transvaal Museum.

Genus TRIBOLODON, Seeley.

Tribolodon frerensis, Seeley.

1895. Seeley, Phil. Trans., B, 185, pl. lxxxviii, 6, 7.
1895. ,, ,, ,, B, 186, p. 145, figs. 33, 34.
1913. Watson, Geol. Mag., p. 147.
Type: lower jaw in British Museum.

Family KARROMYSIDAE.

Genus KARROMYS, Broom.

Karromys browni, Broom.

1903. Broom, Geol. Mag., p. 345.
Type: dentary in South African Museum.

Family TRITYLODONTIDAE.

Genus TRITYLODON, Owen.

Tritylodon longaevus, Owen.

1884. Owen, Quart. Journ. Geol. Soc., xl, p. 146.
1895. ,, Seeley, Phil. Trans., B, 185, p. 1025, pl. lxxxix, 15.
1905. Broom, Trans. S. Afr. Phil. Soc., xvi, p. 73.
1910. ,, P.Z.S., p. 760, figs. 67, 68.
1914. ,, Bull. Amer. Mus. Nat. Hist., xxxiii, p. 119, fig. 1.
1917. Petronievics, Ann. Mag. Nat. Hist., xx, p. 283, pl. x.
Type: anterior part of skull in British Museum.

SUPER-ORDER ICHTHYOPTERYGIA, Nopsca.

ORDER MESOSAURIA, Seeley.

Genus MESOSAURUS, Gervais.

Mesosaurus capensis (Gürich).

1889. Gürich, *Ditrochosaurus capensis*, Zeit. deutschen geol. Gesell., xli, p. 641, pl. xxvii.
1892. Seeley, *M. tenuidens* ?, Quart. Journ. Geol. Soc., xlviii, p. 586.
1908. Broom, Ann. S. Afr. Mus., iv, p. 380.
1914. Strömer, Centralbl. f. Min., p. 530, figs. 1, 2.
Type: probably an immature animal.

Mesosaurus pleurogaster, Seeley.

1892. Seeley, Quart. Journ. Geol. Soc., xlviii, p. 586.
Type: an imperfect animal in British Museum.

Mesosaurus tenuidens, Gervais.

1865. Gervais, Mém. Sec. Sci. Acad. Sci. Montpellier, vi, p. 168.
1869. ,, Zool. et Paléont. générales, i, p. 223, pl. xlii.
1904. Broom, Trans. S. Afr. Phil. Soc., xv, p. 103, pl. ix.
1908. ,, Ann. S. Afr. Mus., iv, p. 379.
Type: front half of animal in Paris Museum.

Genus NOTEOSAURUS, Broom.

Noteosaurus africanus, Broom.

1913. Broom, Ann. S. Afr. Mus., vii, p. 358, fig.
Type: imperfect posterior part of skeleton in South African Museum.

SUPER-ORDER TESTUDINATA.

ORDER EUNOTOSAURIDAE.

Genus EUNOTOSAURUS, Seeley.

Eunotosaurus africanus, Seeley.

1892. Seeley, Quart. Journ. Geol. Soc., xlviii, p. 583, figs. 1–2.
1914. Watson, P.Z.S., p. 1011, pl. vii, and fig. 1.
Type: portion of skeleton in British Museum.

SUPER-ORDER DIAPTOSAURIA.

ORDER EOSUCHIA, Broom.

Genus GALESPHYRUS, Broom.

Galesphyrus capensis, Broom.

1914. Broom, Phil. Trans., B, 206, p. 15, pl. iv, 40.
1921. ,, P.Z.S., p. 153.
Type: a very imperfect skeleton in the South African Museum. The species was first considered to be a Dromasaurian; but Broom now tentatively assigns it to the Eosuchia.

Genus NOTEOSUCHUS, Broom.

Noteosuchus colletti (Watson).

1912. Watson, *Eosuchus colletti*, Rec. Albany Mus., ii, p. 298.
Type: portion of skeleton in Albany Museum.

Family Youngininae, Broom.

Genus YOUNGINA, Broom.

Youngina capensis, Broom.

1914. Broom, P.Z.S. p. 1072, figs. 1, 2.
1921. ,, P.Z.S., p. 151, figs. 19, 20.
1922. ,, ,, p. 21, fig. 4A.
1922. ,, Ann. Transv. Mus., viii, p. 273, fig. 1.
Type: skull in American Museum of Natural History.

Order RHYNCHOCEPHALIA.

Sub-Order Mesosuchidia, Haughton.

Family Howesiidae, Watson.

Genus HOWESIA, Broom.

Howesia browni, Broom.

1905. Broom, Rec. Albany Mus., i, p. 270.
1906. ,, P.Z.S., p. 591, pls. xl, xli.
1921. ,, ,, p. 153, fig. 21.
1921. Haughton, Trans. Roy. Soc. S. Afr., x, p. 87.
Type: an imperfect skull in South African Museum.

Family Mesosuchidae, Haughton.

Genus MESOSUCHUS, Watson.

Mesosuchus browni, Watson.

1912. Watson, Rec. Albany Mus., ii, p. 296.
1913. Broom, ,, ,, ,, ii, p. 394.
1913. ,, P.Z.S., p. 627, pls. lxxviii, lxxix, 12–15, 23.
1921. Haughton, Trans. Roy. Soc. S. Afr., x, p. 85, pl. ii.
1924. ,, ,, ,, ,, xii, p. 17, pls. i, ii.
Type: front of skull, lower jaw, and part of skeleton in South African Museum.

Sub-Order ?

Family Palacrodontidae.

Genus PALACRODON, Broom.

Palacrodon browni, Broom.

1906. Broom, Trans. S. Afr. Phil. Soc., xvi, p. 379, fig.
1907. Nopsca, Centralbl. f. Min., p. 526.
Type: portion of jaw in South African Museum.

ORDER THECODONTIA.

Sub-Order PSEUDOSUCHIA.

Family EUPARKERIIDAE, von Huene.

Genus BROWNIELLA, Broom.

Browniella africana, Broom.

1913. Broom, P.Z.S., p. 627, pl. lxxix, 21.
1921. Haughton, Trans. Roy. Soc. S. Afr., x, p. 85, fig. 6.
Type: femur in South African Museum.

Genus EUPARKERIA, Broom.

Euparkeria capensis, Broom.

1913. Broom, Rec. Albany Mus., ii, p. 394.
1913. ,, P.Z.S., p. 619, pls. lxxv, lxxvi, lxxviii, lxxix, 1–8, 17–20, 22, 24.
1921. Haughton, Trans. Roy. Soc. S. Afr., x, p. 81, pl. ii, 1–5, 7, 8.
Type: skull and part of skeleton in South African Museum.

Family PROTEROSUCHIDAE, von Huene.

Genus PROTEROSUCHUS, Broom.

Proterosuchus fergusi, Broom.

1903. Broom, Ann. S. Afr. Mus., iv, p. 159.
Type: a badly weathered skull in sandstone in South African Museum.

Sub-Order PELYCOSIMIA, von Huene.

Family ERYTHROSUCHIDAE, Watson.

Genus ERYTHROSUCHUS, Broom.

Erythrosuchus africanus, Broom.

1905. Broom, Rec. Albany Mus., i, p. 336.
1906. ,, Ann. S. Afr. Mus., v, p. 187, pl. iv.
1911. von Huene, Geol. u. pal. Abhand., N.F. x, 1, p. 3, pls. i–xi.
Type: bones of girdles and limbs in South African Museum.

ORDER SQUAMATA.

Sub-Order LACERTILIA.

Genus PALIGUANA, Broom.

Paliguana whitei, Broom.

1903. Broom, Rec. Albany Mus., i, p. 1, pl. i, 1–2.
1914. Watson, Ann. Mag. Nat. Hist., ser. 8, xiv, p. 94.
Type: a weathered skull in the Albany Museum.

Order PROTOROSAURIA.

Family Broomidae.

Genus broomia, Watson.

Broomia perplexa, Watson.

1914. Watson, P.Z.S., p. 995, pl. vi, and figs. 1–5.
1921. Broom, ,, p. 150, figs. 16–18.

Type: the impression of a partial skeleton in sandstone in the British Museum.

Family Heleosauridae.

Genus heleosaurus, Broom.

Heleosaurus scholtzi, Broom.

1907. Broom, Trans. S. Afr. Phil. Soc., xviii, p. 39, pl. iv, 7–11.
1914. Watson, P.Z.S., p. 1007.

Type: part of skeleton in South African Museum.

Genus heliophilus, Broom.

Heliophilus acutus, Broom.

1909. Broom, Ann. S. Afr. Mus., vii, p. 277.

Type: a crushed and fragmentary skeleton in South African Museum.

Family Saurosternidae.

Genus saurosternon, Huxley.

Saurosternon baini, Huxley.

1868. Huxley, Geol. Mag., v, p. 201, pl. xi.
1876. Owen, Cat. Foss, Rept. S. Afr., p. 69, pl. lxx, 3.
1910. Broom, Trans. Roy. Soc. S. Afr., ii, p. 25.

Type: partial skeleton in British Museum.

Genus Heleosuchus, Broom.

Heleosuchus griesbachi (Owen).

1876. Owen, *Saurosternon griesbachi*, Cat. Foss. Rept. S. Afr., pl. lxx, 4.
1904. Broom, Rec. Albany Mus., i, p. 177.
1913. ,, Ann. S. Afr. Mus., vii, p. 365.

Type: part of skeleton in Vienna Museum.

In the following table an attempt has been made to assign each form to its proper position in one of the recognised zones. A **X** in the left of a column indicates that the form is from the lower part of the zone: in the right, that it is from the upper part: on a line, that it is at the junction of two zones.

	Upper Dwyka Shales.	Ecca Beds.			Lower Beaufort Beds.			Middle Beaufort Beds.	Upper Beaufort Beds.	
		Lower.	Middle.	Upper.	Tapinocephalus Zone.	Endothiodon Zone.	Cistecephalus Zone.	Lystrosaurus Zone.	Procolophon Zone.	Cynognathus Zone.
COTYLOSAURIA.										
Pareiasauria.										
Anthodon serrarius . . .							× ×			
Bradysaurus baini					×					
Bradysaurus bombidens . . .					×					
Bradysaurus whaitsi . . .					×					
Embrithosaurus schwarzi . .					×					
Pareiasaurus serridens . . .						×				
"Pareiasaurus" strubeni . .					×					
Pareiasuchus peringueyi . . .						×				
Proppapus omocratus . . .					×					
Propappus parvus						×				
Propappus rogersi						×				
Propappus roussowi . . .					?					
Propappus ? acutirostris . .					×					
Procolophonia.										
Procolophon trigoniceps . . .									×	
Thelegnathus browni . . .										×
Thelegnathus parvus . . .										×
THERAPSIDA.										
DINOCEPHALIA.										
Tapinocephalia.										
Delphinognathus conocephalus .					×					
Eccasaurus priscus. . . .				×						
Mormosaurus seeleyi . . .					×					
Moschognathus whaitsi . . .					×					
Moschops capensis					×					
Pelosuchus priscus . . .					×					
Phocasaurus megischion . . .					×					
Pr igalion oweni					×					
Struthiocephalus whaitsi. . .					×					
Tapinocephalus atherstonei . .					×					
Taurops macrodon . . .					?					

	Upper Dwyka Shales.	Ecca Beds.			Lower Beaufort Beds.			Middle Beaufort Beds.	Upper Beaufort Beds.	
		Lower.	Middle.	Upper.	Tapinocephalus Zone.	Endothiodon Zone.	Cistecephalus Zone.	Lystrosaurus Zone.	Procolophon Zone.	Cynognathus Zone.
Titanosuchia.										
Anteosaurus magnificus . . .					×					
Dinophoneus ingens . . .					×					
Enobius strubeni . . .					×					
Jonkeria truculens . . .					×					
Lamiasaurus newtoni . . .					×					
Scapanodon duplessisi . . .					×					
Titanosuchus cloetei . . .					×					
Titanosuchus dubius . . .					×					
Titanosuchus ferox . . .					×					
Dinartamus vanderbyli . . .					×					
Moschosaurus longiceps . . .					×					
DROMASAURIA.										
Galechirus scholtzi						×				
Galepus jouberti					×					
Galeops whaitsi					×					
Macroscelesaurus janseni . .						?				
ANOMODONTIA.										
Bainia haughtoni						×	×			
Bainia laticeps							×			
Bainia peavoti						×	×			
Bainia tigriceps						×				
Chelyrhynchus lachrymalis . .						×				
Dicynodon alticeps . . .						×				
Dicynodon andrewsi . . .						×	×			
Dicynodon bolorhinus . . .						×	×			
Dicynodon breviceps . . .							?			
Dicynodon brevirostris . . .							×			
Dicynodon cavifrons . . .						×				
Dicynodon corstorphinei. . .						×				
Dicynodon curtus							×			
Dicynodon cyclops. . . .						×				
Dicynodon dubius							?			
Dicynodon feliceps. . . .						×				
Dicynodon gracilis . . .						×				
Dicynodon grandis. . . .							×			
Dicynodon halli						×	×			
Dicynodon ictidops . . .						×				
Dicynodon ictinops . . .							×			
Dicynodon ingens							×			
Dicynodon jouberti . . .					×					
Dicynodon kolbei							×			
Dicynodon lacerticeps . . .							×			
Dicynodon leoniceps . . .							×			

	Upper Dwyka Shales.	Ecca Beds.			Lower Beaufort Beds.			Middle Beaufort Beds.	Upper Beaufort Beds.	
		Lower.	Middle.	Upper.	Tapinocephalus Zone.	Endothiodon Zone.	Cistecephalus Zone.	Lystrosaurus Zone.	Procolophon Zone.	Cynognathus Zone.
Dicynodon leontops . . .							×			
Dicynodon lissops							×			
Dicynodon lutriceps . . .						×				
Dicynodon macrorhynchus . .							×			
Dicynodon magnus . . .						×				
Dicynodon megalops . . .							×			
Dicynodon megalorhinus . .					×					
Dicynodon moschops . . .							×			
Dicynodon mustoi . . .							×			
Dicunodon osborni. . . .								×		
Dicynodon planus							×			
Dicynodon platyceps . . .							×			
Dicynodon prognathus . . .						?				
Dicynodon psittacops . . .						×				
Dicynodon pygmaeus . . .							×			
Dicynodon recurvidens . . .						?				
Dicynodon rogersi							×			
Dicynodon schwarzi . . .						×				
Dicynodon sollasi							×			
Dicynodon strigiceps . . .							×			
Dicynodon testudiceps . . .							?			
Dicynodon testudirostris. . .							×			
Dicynodon truncatus . . .							?			
Dicynodon tylorhinus . . .							×			
Dicynodon watsoni . . .							×			
Dicynodon whaitsi. . . .						×	×			
Dicynodon woodwardi . . .							×			
Diictodon galeops						?				
Eocyclops longus						×	×			
Eosimops newtoni						×				
Kannemeyeria erithrea . . .										×
Kannemeyeria latifrons . . .										×
Kannemeyeria simocephalus . .										×
Lystrosaurus alfredi . . .								×		
Lystrosaurus andersoni . . .								×		
Lystrosaurus boopis . . .								×		
Lystrosaurus breyeri . . .								×		
Lystrosaurus declivis . . .								×		
Lystrosaurus depressus . . .								×		
Lystrosaurus frontosus . . .								×		
Lystrosaurus jorisseni . . .								×		
Lystrosaurus latirostris . . .								×		
Lystrosaurus maccaigi . . .								×		
Lystrosaurus murrayi . . .								×		
Lystrosaurus oviceps . . .								×		
Lystrosaurus platyceps . . .								×		
Lystrosaurus putterilli . . .								×		

	Upper Dwyka Shales.	Ecca Beds.			Lower Beaufort Beds.			Middle Beaufort Beds.	Upper Beaufort Beds.	
		Lower.	Middle.	Upper.	Tapinocephalus Zone.	Endothiodon Zone.	Cistecephalus Zone.	Lystrosaurus Zone.	Procolophon Zone.	Cynognathus Zone.
Lystrosaurus theileri . . .								×		
Lystrosaurus verticalis . . .								×		
Lystrosaurus wageri . . .								×		
Lystrosaurus wagneri . . .								×		
Myosaurus gracilis . . .								×		
Palemydops platysoma . . .						×				
Prolystrosaurus natalensis . .								×		
Prolystrosaurus strigops . . .								×		
Chelyoposaurus williamsi . . .						?				
Cryptocynodon simus . . .						×				
Diaelurodon whaitsi . . .						×				
Emydops arctatus . . .						×				
Emydops longiceps . . .						×				
Emydops minor . . .						×				
Emydops parvus . . .							?			
Emydopsis longus . . .						×				
Emydopsis platyceps . . .						×				
Emydopsis sciuroides . . .							×			
Emydopsis trigoniceps . . .						×				
Emydorhynchus palustris . .							×			
Emyduranus platyops . . .						×				
Endothiodon angusticeps . .						×				
Endothiodon bathystoma . .						×				
Endothiodon crassus . . .						×				
Endothiodon paucidens . . .						×				
Endothiodon platyceps . . .						×				
Endothiodon seeleyi . . .						×				
Endothiodon uniseries . . .						×				
Endothiodon whaitsi . . .						×				
Pristerodon agilis . . .						×				
Pristerodon brachyops . . .						?				
Pristerodon mackayi . . .						×				
Pristerodon raniceps . . .						×				
Prodicynodon beaufortensis . .						×				
Prodicynodon pearstonensis . .						×				
Taognathus megalodon . . .						×				
Tropidostoma microtrema . .					?					
THERIODONTIA.										
Therocephalia.										
Alopecopsis atavus . . .							×			
Arnognathus parvidens . . .						×				
Cerdodon tenuidens . . .					×					
Ictidosuchus longiceps . . .							?			
Ictidosuchus primaevus . . .						×				
Alopecodon priscus . . .					×					

	Upper Dwyka shales.	Ecca Beds. Lower.	Ecca Beds. Middle.	Ecca Beds. Upper.	Lower Beaufort Beds. Tapinocephalus Zone.	Lower Beaufort Beds. Endothiodon Zone.	Lower Beaufort Beds. Cistecephalus Zone.	Middle Beaufort Beds. Lystrosaurus Zone.	Upper Beaufort Beds. Procolophon Zone.	Upper Beaufort Beds. Cynognathus Zone.
Alopecodon rugosus . . .					×					
Alopecognathus angusticeps . .					×					
Alopecognathus minor . . .					×					
Alopecorhinus parvidens. . .						×				
Broomisaurus planiceps . . .					×					
Glanosuchus macrops . . .					×					
Hyaenasuchus whaitsi . . .					×					
Ictidosaurus angusticeps. . .					×					
Lycosuchus mackayi . . .						×				
Lycosuchus vanderrieti . . .					×					
Moschorhinus kitchingi . . .								×		
Pardosuchus whaitsi . . .					×					
Pristerognathus baini . . .					×					
Pristerognathus polyodon . . .					×					
Pristerognathus platyrhinus . .					×					
Scylacoides ferox						×				
Scylacorhinus falkenbachi . .					×					
Scylacosaurus sclateri . . .							×			
Scymnosaurus ferox . . .					×					
Scymnosaurus warreni . . .						?				
Scymnosaurus watsoni . . .					×					
Trochosaurus intermedius . .					×					
Trochosuchus acutus . . .					×					
Trochosuchus major . . .					×					
Akidnognathus parvus . . .							×			
Icticephalus polycynodon . .						×				
Ictidognathus hemburyi . . .						×				
Ictidognathus parvidens . .							×			
Scaloposaurus constrictus . .							×			
Simorhinella baini					?					
Whaitsia platyceps . . .							×			
Gorgonopsia.										
Aelurognathus serratidens . .						×				
Aelurognathus tigriceps . . .						×				
Aelurosaurus felinus . . .						×				
Aelurosaurus striatidens . . .						×				
Aelurosaurus tenuirostris . .							×			
Aelurosaurus whaitsi . . .						×				
Aloposaurus gracilis . . .						×				
Arctognathus curvimola . . .							?			
Arctognathus whaitsi . . .							×			
Arctops willistoni						?				
Arctosuchus tigrinus . . .						×				
Asthenognathus paucidens . .							×			
Cerdognathus greyi . . .							×			

	Upper Dwyka Shales.	Ecca Beds.			Lower Beaufort Beds.			Middle Beaufort Beds.	Upper Beaufort Beds.	
		Lower.	Middle.	Upper.	Tapinocephalus Zone.	Endothiodon Zone.	Cistecephalus Zone.	Lystrosaurus Zone.	Procolophon Zone.	Cynognathus Zone.
Cynochampsa laniaria							?			
Cynodraco serridens						×				
Eriphostoma microdon					×					
Galesuchus gracilis					×					
Gorgonognathus longifrons						×	×			
Gorgonops torvus						×				
Ictidorhinus martinsi							×			
Leptotrachelus eupachygnathus						×				
Lycosaurus pardalis							×			
Scylacognathus parvus					×					
Scylacops capensis						×	×			
Scymnognathus angusticeps							×			
Scymnognathus minor							×			
Scymnognathus parvus						×				
Scymnognathus whaitsi						×				
Sycosaurus laticeps							×			
Tigrisuchus simus							?			
Burnetiamorpha.										
Burnetia mirabilis								?		
Bauriamorpha.										
Aelurosuchus browni										×
Bauria cynops										×
Melinodon simus										×
Microgomphodon oligocynus										×
Sesamodon browni										×
Cynodontia.										
Cynidiognathus broomi										×
Cynidiognathus longiceps										×
Cynognathus berryi										×
Cynognathus crateronotus										×
Cynognathus platyceps										×
Lycochampsa ferox										×
Cyniscodon lydekkeri					?					
Cynosuchus suppostus							×			
Cynosuchus whaitsi							×			
Cyclogomphodon platyrhinus										×
Diademodon tetragonus										×
Gomphognathus browni										×
Gomphognathus mastacus										×
Octagomphus woodi										×
Protacmon brachyrhinus										×
Trirachodon berryi										×
Trirachodon browni										×

	Upper Dwyka Shales.	Ecca Beds.			Lower Beaufort Beds.			Middle Beaufort Beds.	Upper Beaufort Beds.	
		Lower.	Middle.	Upper.	Tapinocephalus Zone.	Endothiodon Zone.	Cistecephalus Zone.	Lystrosaurus Zone.	Procolophon Zone.	Cynognathus Zone.
Trirachodon kannemeyeri . .										×
Trirachodon minor. . . .										×
Galesaurus planiceps . . .								×		
Glochinodon detinens . . .								×		
Ictidopsis elegans								×		
Nythosaurus browni . . .										×
Nythosaurus larvatus . . .								?	?	
Platycraniellus elegans . . .								×		
Tribolodon frerensis . . .										×
Karromys browni										×
Tritylodon longaevus . . .										×
ICHTHYOPTERYGIA.										
MESOSAURIA.										
Mesosaurus capensis . . .	×									
Mesosaurus pleurogaster . .	×									
Mesosaurus tenuidens . . .	×									
Noteosaurus africanus . . .	?									
TESTUDINATA.										
EUNOTOSAURIDAE.										
Eunotosaurus africanus . . .					×					
DIAPTOSAURIA.										
EOSUCHIA.										
Galesphyrus capensis . . .				?						
Noteosuchus colletti . . .							?			
Youngina capensis . . .							×			
RHYNCHOCEPHALIA.										
Mesosuchidia.										
Howesia browni										×
Mesosuchus browni . . .										×
?										
Palacrodon browni . . .										×
THECODONTIA.										
Pseudosuchia.										
Browniella africana . . .										×
Euparkeria capensis . . .										×
Proterosuchus fergusi . . .									×	
Pelycosimia.										
Erythrosuchus africanus. . .										×

	Upper Dwyka Shales.	Ecca Beds.			Lower Beaufort Beds.			Middle Beaufort Beds.	Upper Beaufort Beds.	
		Lower.	Middle.	Upper.	Tapinocephalus Zone.	Endothiodon Zone.	Cistecephalus Zone.	Lystrosaurus Zone.	Procolophon Zone.	Cynognathus Zone.
SQUAMATA.										
Lacertilia.										
Paliguana whitei . . .									×	
PROTOROSAURIA.										
Broomia perplexa					×					
Heleosaurus scholtzi . . .						×				
Heliophilus acutus . . .						×				
Saurosternon baini . . .							×			
Heleosuchus griesbachi . . .							?			

Kops, C. W.—A South African Life Table based on the European Male Population Census.

Trans. R. Soc. S. Afr., vol. xii, 1925, p. 301.

Mr Kops desires to acknowledge the receipt of financial assistance from the Research Grant Board of the Union of South Africa.

THE NON-MARINE MOLLUSCA OF PORTUGUESE EAST AFRICA.

By M. CONNOLLY.

(With Plates IV to VIII and thirty Text-figures.)

CONTENTS.

INTRODUCTION.

Peculiarly little has hitherto been written about the molluscs inhabiting the large tract of Portuguese territory in East Africa, which is divided into Mozambique, on the north, and Lorenzo Marques, on the south, by the R. Zambesi.

While Portuguese West Africa has been pretty thoroughly searched by various explorers since the days of Welwitsch, and the results fully treated by Morelet and Nobre, hardly any early traveller seems to have done much

collecting on the immediately opposite side of the continent except the Englishman, Sir John Kirk, and the German, Dr. W. Peters.

The latter travelled along the east coast and up the Zambesi between 1843 and 1847, and his collection, lists of which were published by von Martens in 1860, 1869, and 1879, seems to have totalled the thirty-four following non-marine species:—

Ledoulxia mozambicensis (Pfr.).
„ *albopicta* (Mts.).
„ *jenynsi* (Pfr.).
Trachycystis pinguis (Krs.).
Rhachis punctata (Anton).
„ *petersi* (Pfr.).
„ *catenata* (Mts.).
Rhachidina melanacme (Pfr.).
„ *spilogramma* (Mts.).
Rhachistia sticta (Mts.).
Achatina panthera (Fér.).
„ *petersi* Mts. (a synonym of *A. glutinosa* Pfr.).
Urocyclus fasciatus (Mts.).
„ *flavescens* (Kfstn.).
Veronicella petersi (Mts.).
Onchidium peroni Cuv.
Limnaea natalensis Krs.
Physa mosambiquensis Cless.
Physopsis africana Krs.
Tropidophora ligata (Müll.).
Melanoides tuberculatus (Müll.) (cum *M. inhambanicus* (Mts.), a large form of *tuberculatus*).
Tiara vouamica Bgt. (recorded by von Martens under the name of *Melania crenularis* Desh.).
Ampullaria largillierti Phil.
Lanistes ovum (Ptrs.).
„ *purpureus* (Jonas) (a synonym of *L. olivaceus* Sow.).
Theodoxus natalensis (Rve.).
„ *knorri* (Recl.).
Truncatella teres Pfr.
Spatha wahlbergi (Krs.).
„ *petersi* Mts.
Indonaia mossambicensis (Ptrs.).
Mutela coelestis Lea (a synonym of *M. rostrata* Rang).
Corbicula astartina Mts., and
„ *radiata* (Parr.), which must now be known as *africana* Krs.

Kirk, who only died as recently as January 1922, did much exploring on Livingstone's staff between 1858 and 1863, and was subsequently attached to the British Embassy at Zanzibar from 1866 till 1887. His early conchological discoveries were recorded by Dohrn, Gray, Lea, and Prime, and added the 5 following species to the fauna under notice: *Urocyclus kirki* Gray; *Pseudoglessula kirki* (Dhrn.); *Tropidophora calcarea* (Sow.); *Cor-*

bicula kirki (Prime); and a shell which Dohrn identified as *Cleopatra bulimoides* (Oliv.).

Achatina panthera (Fer.) and *lamarckiana* Pfr. were both included in Dohrn's list, but as the latter is a synonym of the former it need not enter into consideration.

Only six other expeditions of the nineteenth century added much to our knowledge of Portuguese East African mollusca.

Among shells sent by Plant to Cuming in the early fifties, as from Cape Delagoa, were *Gulella kraussi* (Pfr.) and *wahlbergi* (Krs.); *Trachycystis aenea* (Krs.); *Achatina granulata* and *natalensis* Pfr. He also furnished these species at the same time from "Cape Natal," and as three of them have not been found subsequently near Delagoa Bay, it is not improbable that the records of the localities became mixed.

In 1879 J. S. Gibbons published a list of species collected by himself between Delagoa Bay and Zanzibar, while other of his finds were described by J. W. Taylor and W. Nelson; fresh additions were *Achatina immaculata* (Lam.), *Rhachidina mozambicensis* (Pfr.),* *Pseudoglessula gibbonsi* (Taylor), *Veronicella natalensis* (von Rapp), *Tropidophora zanguebarica* (Petit), and *kraussiana* (probably a misidentification of *insularis*) (Pfr.), while to these must be added a slug which Gibbons considered to be *Urocyclus flavescens*, but which has since been made the type of a new genus under the name of *Kirkia gibbonsi* (see p. 138).

Capello and Ivens travelled across Africa, just north of the Zambesi, in 1884–85, and a first instalment, never continued, of their collection was published by Furtado in 1886. It added nothing in reality, however, to the fauna now under notice, since such new species and varieties as were founded on examples from Portuguese East African territory have subsequently been relegated to synonymy.

Dr. Stuhlmann visited the south-east coast in the spring of 1889, and a list of 10 species, given by von Martens in 1897, added *Isidora forskali* Ehrn., *Tropidophora letourneuxi* (Bgt.), and *Cleopatra ferruginea* (Lea) [recorded as *amoena* Morel.], to the local list.

Dr. Penther collected in South Africa in 1897, and among his valuable acquisitions, recorded by Sturany in 1898, the following additions were ascribed to the Delagoa district :—

Gulella perissodonta (Stur.).
,, *perspicuaeformis* (Stur.).
Natalina caffrula, M. and P.
Pseudoglessula movenensis (Stur.) (a synonym of *boivini*, Morelet).

* Described from the Cuming collection in 1846, but without mention of the collector's name.

Rhachidina dubiosa (Stur.).
,, *pentheri* (Stur.) (a synonym of *R. usagarica* (Smith)).
Conulinus meridionalis (Pfr.).
,, *natalensis var.* (Krs.).
Caecilioides ovampoensis (M. and P.).

Finally, about 1899, the Rev. H. A. Junod sent home some fine material from the same district and Inhambane, but the paper in which it is recorded presents so many instances of obvious misidentification that the list, as published, is of doubtful value. It contained 17 non-marine species, of which 9 had not been previously chronicled from Portuguese East Africa, viz. :—

Natalina caffra, var. *wesseliana* (Maltzan).
Kerkophorus poeppigi (Mke.).
Conulinus conulus (Rve.).
Metachatina kraussi, var. *elongata*, Junod.
Achatina schinziana Mousson.
Limnaea natalensis Krs.
Planorbis rüppelli Dkr.
Isidora natalensis (Krs.).
Vivipara capillata Frnfd.

Of these, although I am rather doubtful as to the correct identification of some of the species which I have not examined, their extension up or down the coast to Delagoa is by no means improbable ; I prove later on, however, that the Kalaharian *A. schinziana* and Abyssinian *P. rüppelli* are misnomers for *A. granulata* Pfr. and *P. pfeifferi* Krs.

In the first decade of the present century the only recorded collection was made by A. Vasse in the Andrada mining district, the list of which, published by Germain in 1918, added *Tropidophora anceps* (Mts.), *Achatina vassei*, and *Rhachistia rhodotaenia*, var. *andradensis* Germain to the local fauna.

In addition to the foregoing, 9 other species have been recorded at various times, by different writers, from Portuguese East Africa, so it will be seen that up to the year 1920 the number of non-marine mollusca known to inhabit the entire territory amounted to only 84 species, of which 55 are terrestrial and 29 aquatic.

During the last ten years, however, I have been extraordinarily fortunate in opportunities of studying much fresh material from all over Lorenzo Marques.

Mr. Bernard Cressy has kindly furnished me with a splendid series of shells from the Macequece District, in which the Andrada Mines are situated, and from other more northerly parts of the country ; through the kindness

of Mr. John Reed, Secretary of the Beira and Mashonaland Railway, I have received two interesting little collections made by B. F. Mcdowell at stations on that line; while the Rev. H. A. Junod has renewed his valuable researches in the southern portion of the territory, and Miss Wilman, Director of the M'Gregor Museum, Kimberley, most kindly arranged that his fine collection should be submitted to me for examination. Finally, I am much indebted to Messrs. K. H. Barnard and H. C. Burnup for the sight of still further material collected by H. W. Bell Marley in the Magude district, and Dr. F. G. Cawston at Beira and Delagoa Bay.

The natural result is the addition of very many new names to the South African faunal list, as well as to that of Portuguese East Africa; in fact, the latter is almost doubled by the recent discoveries, the present record comprising 111 land and 43 aquatic species, a total of 154, as against that of 84 just mentioned.

As might be expected, the Portuguese territory is a half-way house between South and Central African forms. From Delagoa Bay, in the south, hardly a species is recorded which is not also common to the Transvaal or Natal, but north of the Beira railway, whence most of the new material is derived, southern forms become inconspicuous or disappear, and the larger species are more characteristic of the fauna of tropical Africa than of the more temperate southern part of the continent, several having already been described from Nyasaland or further north.

An exact analysis shows that, of the 154 species now listed, 68 have not yet been collected outside the latitudes of Portuguese East Africa; 21 are common to districts both north and south of that territory; 27 are only recorded otherwise from Central, and 38 from South Africa, but 23 of these hail from the Delagoa district, and some of them are very doubtfully authenticated. Only 35 species are yet chronicled from Mozambique, none of which is a purely South African form, while no fewer than 9 are unknown south of the Zambesi.

In addition to many friends, whose kind assistance in the preparation of this work is acknowledged elsewhere, I must express above all my extreme indebtedness to H. Watson for his great kindness in reporting on the anatomy of many of the species. The whole of the anatomical details are solely from his pen, as are the many text-figures and four beautiful plates in illustration of his letterpress.

The following list sets forth in generic sequence all the land and freshwater mollusca, as far as I can trace the records, which are believed to inhabit Mozambique and Lorenzo Marques. Few references to literature are appended, as these were either given in full in my Revised Reference List,* or will be included in a supplement thereto, now in course of preparation.

* Ann. S. Afr. Mus., xi, 1912, pp. 59–307.

In some cases, therefore, I have not given the earliest reference to a species, when no figure was presented with it, but have given the original date of its description, and a later reference, usually by the same author, to a work in which both description and figure may be found. The letters D, F, L, N, A, R, appended to references, denote respectively Description, Figure of shell or slug, Locality, Note, Anatomy, and Radula.

The rough map on p. 111 shows nearly every locality mentioned in Lorenzo Marques; the few in Mozambique are easily found in any atlas.

Unless otherwise mentioned, the types of all species described by the present author are in his collection.

GASTROPODA.

Family STREPTAXIDAE.

The arrangement which follows of this family is that adopted by Pilsbry in his work on the Belgian Congo, 1919 (Bull. Amer. Mus. N. H. xl.).

Subfamily STREPTAXINAE.

Genus Gonaxis, Taylor, 1877.

Gonaxis gwandaensis (Prest.), 1912.

1912. *Streptaxis gwandaensis* Prest., A.M.N.H. ix, p. 69, f. 1. D.F.

Hab. L. Marques. Wanetsi River, Magude District (Bell Marley).

A very typical example of this rare species, only known hitherto from its original locality in Southern Rhodesia. It is perfectly figured by Preston.

Gonaxis kirki (Dhrn.), 1865.

1865. *Streptaxis kirki* Dhrn., P.Z.S., p. 232. D.

1905. „ (*Gonaxis*) *kirkii* Dhrn., Kob., Conch. Cab., p. 8, pl. 42, f. 14–15. D.F.

Hab. L. Marques. Mtisherra R. Valley (Cressy).

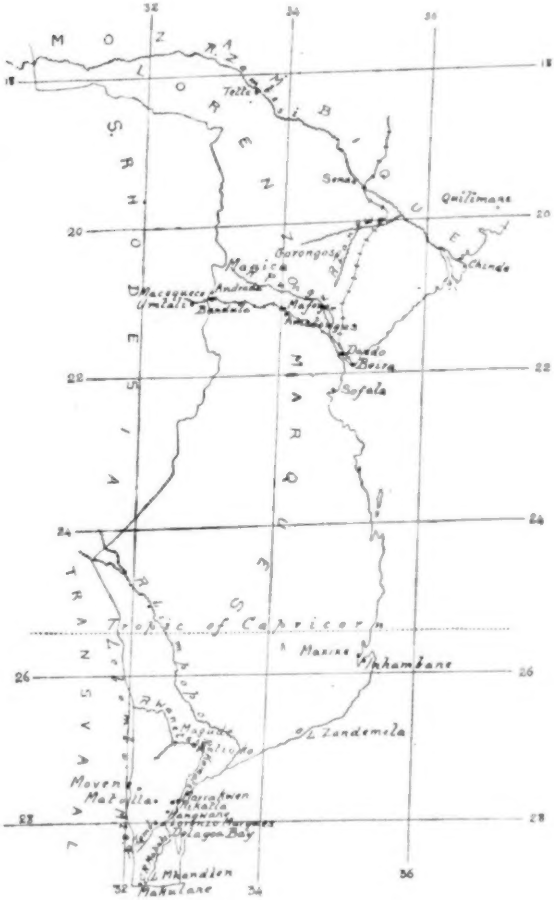
A well-sculptured shell of moderate size, with extremely distorted axis. It was described from Mumba I., Lake Nyasa, and is the first of several species from Nyasaland to be noticed in the following pages.

Gonaxis cressyi Conn., 1922.

(Plate IV, fig. 1.)

1922. *Gonaxis cressyi* Conn., A.M.N.H. x, p. 113. D.

Hab. L. Marques. Mtisherra R. Valley (type); Dondo; Zangwe Basin (Cressy).



ROUGH MAP OF LORENZO MARQUES.

Showing the approximate position of most of the localities quoted. Of those not shown, Mt. Vengo is about 15 miles north of Macequece; the rivers Tristão and Inyamkarrara are near Andrada; the R. Mtisherra cuts the B. and M. Railway some distance east of Amatongas. I have been unable to find Masiene, Nyiwan, and Mungurumbe on any available atlas, but all three localities are on, or not far from, the coast in the southern portion of the territory.

Nearest to *G. denticulatus* (Dhrn.) (=*ordinarius* Smith) and *G. gibbonsi* Taylor, but differing from both by reason of its rather less distorted axis.

Subgenus EUSTREPTAXIS Pfr., 1878.

Gonaxis (*Eustreptaxis*) *elongatus* (Fulton), 1899.

(Plate V, figs. 1–3.)

1899. *Streptaxis elongatus* Fulton, Proc. Mal. Soc. iii, p. 302, fig. 2. D.F.

Hab. L. MARQUES. District north of Macequece (Cressy).

This fine species was founded on a couple of shells from an unknown locality; it is therefore satisfactory that its true habitat is determined.

The parietal tooth appears to be formed after maturity, as I have seen a specimen in which the reflexion of the peristome is practically complete, but with no sign of the dental process. Young shells are clearly perforate to the apex.

The average size of the species is about 23×14 mm., but I have seen an individual as large as $28 \times 14\frac{1}{2}$ mm., rather suggesting the result of a cross between *elongatus* and *vengoensis*.

Some notes on the anatomy of a young specimen are given below:—

External features and pallial organs.—The foot-sole is undivided, and there are no peripodial grooves. The hind end of the foot is bluntly pointed. There is no keel, but a median posterior groove is present. The two anterior dorsal grooves are rather close together, and, on each side of these, other grooves run forwards and slightly downwards on the neck (Pl. V, fig. 1). The two lower tentacles are apparently bifid, as is sometimes the case in carnivorous snails.

The right body-lobe is rather large; the left is divided into a broad right portion, and a small, triangular left portion, as shown in the upper part of fig. 1.

The main pulmonary vein has a number of slender branches. The kidney seems to be rather short. The ureter arises from the front end of the kidney, runs back along its upper edge, and then curves round and runs forward just below the rectum. It appears to be closed throughout.

Internal characters.—The pedal gland, which lies in the lower part of the body-cavity, is long and somewhat contorted. It is broad for the 3 or 4 mm. of its length that lie in front of the ventral nerve-ganglia; but the remaining portion, about 6 mm. long, is much narrower, although still having some glandular tissue.

The cerebral ganglia are much longer than broad (their length being measured in an antero-posterior direction). They are close together, and in the specimen examined they lay in front of the opening of the oesophagus.

The buccal ganglia are situated some distance further back, at the anterior end of the odontophore, and are also close together, the buccal commissure being unusually short.

The muscular odontophore is about 6 mm. long, and is curved as shown in Pl. V, fig. 3. The following are its principal intrinsic muscles: Externally there is a moderately thick sheath composed almost entirely of muscle-fibres running in a circular direction. When this is cut open, another cylindrical structure is disclosed within the outer sheath, the bottom and sides of which are formed of the semitranslucent odontophoral support or "cartilage," while the top consists of a thick compact layer of transverse muscle-fibres uniting the two edges of the support (text-fig. 1 B). There also arises from the outer edge of the support on each side a longitudinal series of slender muscles, which curve downwards and unite with the outer sheath. Towards the front end of the odontophore other slender muscles arise from the same place, but curve upwards and unite with the top of the sheath. These suspensor muscles are dotted in the diagram. The anterior part of the radula is folded over the front of the odontophoral support, and extends backwards beneath its anterior half, in a posterior ventral pocket of the buccal cavity. A broad longitudinal muscle runs back from the hind end of this pocket, as shown in the section and in Pl. V, fig. 2. The latter figure also shows the powerful longitudinal retractors of the radula-sac, as seen after the removal of the odontophoral support and the transverse muscles connected with it. Most of these retractors are inserted close to the front end of the narrow radula-sac, which they practically surround. Of these the lowest pair of muscles is the largest, while those above the radula-sac consist of a number of small, separate strands. These latter muscles arise all along the edges of the odontophoral support, but the larger muscles below them seem all to have their origin at the posterior end of the support. In addition to these muscles inserted near the front end of the radula-sac, an unusually stout terminal retractor is inserted at its extreme hind end, and this muscle appears to be continuous with the extrinsic buccal retractor.

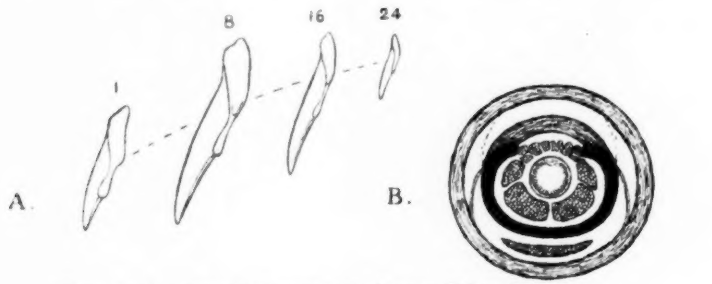
The radula itself is long and rather narrow, measuring about $8{\cdot}4 \times 1{\cdot}4$ mm. when flattened out. The teeth are all unicuspid, being of the aculeate type characteristic of the family, as will be seen from text-fig. 1 A. The rows form a conspicuous angle in the middle, and no central teeth are present. The teeth towards the middle of each row have somewhat shorter cusps than the others, but on the whole the shape of the teeth is fairly uniform. They gradually increase in size from the first until about the sixth on each side, and then become smaller again from about the tenth tooth to the edge of the radula.

Perhaps the most striking feature of the radula, doubtless mainly due

to its immaturity, is the great increase in the size of the teeth as they are followed backwards, those in the last rows of the radula being more than twice as large as those at the front end. Thus the length of the fourth tooth from the centre is ·125 mm. in the first few rows and ·255 mm. in the last. The distance between adjacent rows is proportionately increased towards the hind end, and at the same time the angle in the centre of each row becomes somewhat sharper, decreasing from about 130° in front to about 90° behind.

The radular formula is $(24+0+24) \times 86$.

The buccal mass in front of the odontophore is long and rather narrow, and extends backwards nearly 2 mm. behind the opening of the oesophagus.



TEXT-FIG. 1.—*Gonaxis* (*Eustreptaxis*) *elongatus* Fulton, Macequece.

A. Representative teeth from the radula of a young specimen; $\times 140$.
B. Diagrammatic transverse section through the odontophore of the same specimen.

The odontophore is thus situated much further back than usual (Pl. V, fig. 3). Possibly this elongation of the buccal mass may be in order to enable the odontophore to be thrust out further when the walls of the buccal mass are evaginated. In the specimen examined only the lips and the extreme front end of the buccal mass were protruded (fig. 1).

The oesophagus is not dilated to form a crop. The intestine is straighter, and, consequently, shorter, than usual, a modification often found in carnivorous animals.

The muscular system is also somewhat specialised. The columellar muscle consists of two main divisions, a broad and powerful ventral muscle to the foot, the so-called tail retractor, and another muscle, which first gives off the short, stout buccal retractor, and much further forward divides into both the right and the left tentacular retractors and the other muscles of the front of the head.

As the specimen examined was quite a young example, its reproductive organs were not sufficiently developed for description.

Gonaxis (*Eustreptaxis*) *vengoensis* Conn., 1922.

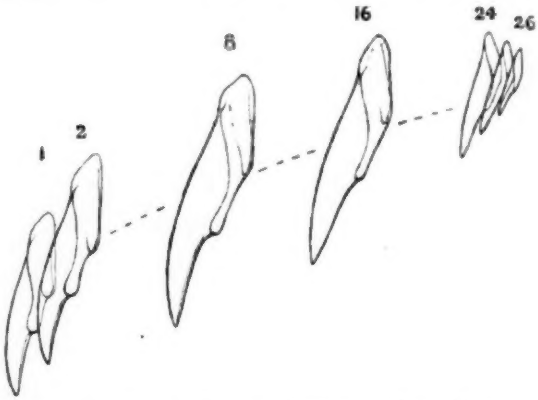
(Plate IV, fig. 2.)

1922. *Gonaxis* (*Eustreptaxis*) *vengoensis* Conn., A.M.N.H. x, p. 114. D.

Hab. L. MARQUES. District 15 miles N. of Macequece (Cressy).

A fine species, showing little variation in a good series collected at different times in various parts of the district. Immature shells are helicoid in form, roundly umbilicate, and bluntly keeled at the periphery, below which there is hardly any sculpture.

The animal differs from that of *Gonaxis* (*Eustreptaxis*) *elongatus* (Fulton)



TEXT-FIG. 2.—*Gonaxis* (*Eustreptaxis*) *vengoensis* Conn., Macequece. Representative teeth from the radula ; $\times 100$.

in having numerous dark spots scattered over the roof of the mantle-cavity, whereas in *S. elongatus* there is only a single dark patch near the respiratory orifice. In most other respects, however, the animals of the two species seem to be very similar, and they are probably fairly closely related. Their radulae are remarkably like each other, although in the present species the cusps of the inner teeth seem to be slightly more curved and somewhat longer relatively to the length of the bases of the teeth. The number of teeth in each transverse row is 26+0+26. They gradually increase in size from the first to the sixth tooth on each side, and diminish again from about the thirteenth tooth to the outer edge of the radula. In a full-grown specimen the sixth to the thirteenth teeth may all attain a length of about ·4 mm. (text-fig. 2).

The character of the radula shows that this species is better placed in the subgenus *Eustreptaxis*, rather than in the closely related genus *Marconia* ;

for in the species of *Marconia* that have been examined anatomically it has been found that the radula is of a somewhat specialised type, with two longitudinal zones of large teeth on each side separated by a zone of smaller teeth.*

Subfamily PTYCHOTREMATINAE.

Genus Gulella Pfeiffer, 1856.

Gulella perissodonta (Sturany), 1898.

1898. *Ennea perissodonta* Stur., S.A. Moll., p. 26, pl. 1, fig. 18. D.F.

Hab. L. Marques. Delagoa Bay (Penther).

Founded on a single specimen, which is described as having 9 teeth in the aperture. It is a small form, measuring 4·0×2·0 mm.

Gulella enneodon Conn., 1922.

(Plate IV, fig. 3.)

1922. *Gulella enneadon* Conn., A.M.N.H. x, p. 114. D.

Hab. L. Marques. District N. of Macequece (Cressy).

The type, 6·2×3·3 mm., with 7½ whorls, is of intermediate and, on the whole, average size and shape in a species which varies greatly in these respects, for the largest example seen contains 8 whorls, is cylindrical in form, and measures 8·0×3·5; apert. 1·6×1·6; last whorl 4·1 mm.; while a small one containing 7 whorls is truncate-ovate, and measures 5·8×3; apert. 1·5×1·2; last whorl 3·3 mm.

The sculpture and dentition are remarkably constant throughout a large series, the nine teeth being almost invariably conspicuous, though comparatively weaker in the largest examples; I have, however, seen one curious abnormality, in which the large tooth on the outer lip is single, but there is a second, smaller denticle on the left of the base.

The only close affinity of *G. enneodon* is with *G. perissodonta*, but Dr. Sturany, who has kindly compared them, informs me that they are quite distinct. The presence in both species of the mid-parietal denticle and the two small teeth low on the outer lip draws them very near together, but the sculpture of *enneodon* is finer, the aperture comparatively smaller, the whorls more numerous and the suture less deeply incised, which, together with the smaller size of *perissodonta*, should afford ample means of distinction between them.

* Thiele: Deutsch. Zentral-Afrika-Exped. (1907–08), vol. iii, 1912, p. 183, fig. vii (*Marconia latula* (Marts.)); Pilsbry: Bull. Amer. Mus. Nat. Hist., vol. xl, 1919, pp. 172, 173, fig. 61 (*Marconia lata ruwenzoriensis* Pils.); Peile in Connolly: Ann. and Mag. Nat. Hist., ser. 9, vol. x, 1922, p. 488 (*Marconia margarita* (Preston), a form in which the outer large teeth are not quite so well developed as in the two preceding species).

The specific name was inadvertently misspelt in 1922; the correct rendering is *enneodon*.

Gulella sexdentata (von Martens), 1869.

1869. *Ennea laevigata* Dhrn., var. *sexdentata* Mts., Nachr.-Bl. d. Mal. Ges. i, p. 154. D.

1890. *Ennea hanningtoni* Smith, A.M.N.H. vi, p. 161, pl. 6, fig. 4. D.F.

Hab. L. Marques. Mtisherra R. Valley; Dondo; Zangwe Basin (Cressy).

The smooth northern cousin of the southern *G. gouldi* (Pfr.), to which it bears a close general resemblance except for the lack of visible sculpture. The species was originally founded by von Martens as a six-toothed variety of *laevigata*, so there is small wonder that Smith overlooked it when he described and figured it under the name of *hanningtoni*.

Its distribution extends northward as far as Zanzibar, and it has been recently taken at Gwelo in Southern Rhodesia.

Gulella infans (Crvn.), 1880.

1880. *Ennea infans* Crvn., P.Z.S., p. 616, pl. 57, fig. 6. D.F.

Hab. L. Marques. Masiene (Lawrence).

A single small specimen, differing slightly from typical *infans*, but resembling a set in my collection from Matopos, Rhodesia. The striation is weaker, the sinulus more pronounced, and the tooth on the outer lip a little nearer the paries than in *infans*, but all these discrepancies are very slight. Moreover, Watson reports that there is no marked difference between the male organs in the anatomy of the Matopos animals and those of typical *infans* from Pietersburg, Transvaal; in the radula of the former, the teeth are slightly broader and a little less strongly curved towards their anterior ends, and there are not quite so many of them in each transverse row as in *infans*. These differences, however, are very small, distinctly less than those that separate the radulae of *infans* and *tristãoensis*, and in his opinion do not prove that the Matopos examples belong to a distinct species.

Gulella praelonga Conn., 1922.

(Plate IV, fig. 5.)

1922. *Gulella praelonga* Conn., A.M.N.H. x, p. 115. D.

Hab. L. Marques. Mount Vengo, Macequece (Cressy).

The type contains $7\frac{1}{2}$ whorls and measures $8{\cdot}8 \times 3{\cdot}5$ mm. The largest example seen, with $8\frac{1}{2}$ whorls, measures $9{\cdot}6 \times 3{\cdot}4$, and a peculiarly small one, with $7\frac{1}{4}$ whorls, $7{\cdot}2 \times 3{\cdot}0$ mm.

This giant member of the *infans* group calls to mind the Mascarene

genus *Gonospira* Swainson, but differs from it in the presence of a tooth on the outer lip, a character which also separates it from *Gibbulina expatriata* Preston, from Kenya Colony. In fact, there appears to be nothing much like it among African species.

Gulella tristãoensis Conn., 1922.

(Plate IV, fig. 6.)

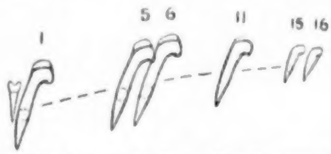
1922. *Gulella tristãoensis* Conn., A.M.N.H. x, p. 115. D.

Hab. L. Marques. District N. of Macequece (Cressy).

The type measures 5·3×2·3 mm.; the last whorl, by which throughout all my works I mean the distance from the extreme base of the aperture to the centre of the suture directly above it, a most important measurement, is 2·8 mm.

The foot of the animal shows distinct peripodial grooves, cutting off a rather broad foot-fringe.

The radula (text-fig. 3) is long and narrow, that of an immature specimen



Text-fig. 3.—*Gulella tristãoensis* Conn., Headwaters of River Tristão. Representative teeth from the radula of an immature specimen; ×500.

measuring 1·9×·25 mm. when flattened out. The teeth are of the aculeate type, and are nearly straight except at the anterior or basal end, where they are abruptly curved outwards as shown in the figure. The central tooth is small and degenerate, although furnished with a distinct, sharply pointed cusp. The other teeth increase very slightly in size from the first to about the fourth on each side, and then diminish again towards the outer margins of the radula, the last two or three teeth being as small as the central tooth, and relatively broader and shorter than the larger teeth, which closely resemble one another in form. The apophyses, which are situated about half-way up the cusps, are extremely low and inconspicuous. The largest teeth in each row measure about ·03 mm. in length, except near the front end of the radula, where they are scarcely ·02 mm. long. In the centre the rows of teeth form an angle of about 120° towards the hinder part of the radula, but the angle becomes more obtuse towards the front end, where the rows are also nearer together, being less than ·01 mm. apart. These differences at the front end of the radula are probably partly due to the immaturity of the specimen. The radular formula is: (17+1+17)×121.

The radula of a specimen of *Gulella infans* (Crvn.), from Pietersburg in the Transvaal, differs somewhat from that described above. The cusps of the teeth are a little shorter relatively to the curved bases; they point more directly backwards; the apophyses are more prominent; and the radula is not so long, the formula being: $(21+1+21)\times 89$.

While disinclined to add another species to the already over-elaborated *infans* group, the Macequece shells differ so greatly from typical *infans* in the appearance of the last whorl that, taking into consideration the difference in the radula, it appears to me that specific, rather than varietal, distinction is advisable.

The measurements of three other shells from Macequece are: shell 4·6, last whorl 2·6; shell 5·0, last whorl 2·8; and shell 5·4, last whorl 2·9 mm., the last whorl thus considerably exceeding half the total length of the shell, whereas in *infans* it averages about one-half of the total length.

Distributed very sparingly with the foregoing are a few examples which would have been mistaken for a distinct species if encountered alone. They are longer and broader than the majority of the local race, with the appearance of weaker sculpture and dentition, though these features are really normal, the apparent weakness being due to the superior size of the shells.

Two specimens measure $6{\cdot}7\times 2{\cdot}9$, last whorl 3·4; and $6{\cdot}3\times 2{\cdot}6$, last whorl 3 mm., respectively.

Gulella perspicuaeformis (Sturany), 1898.

1898. *Ennea perspicuaeformis* Stur., S.A. Moll., p. 17, pl. 1, fig. 2. D.F.

Hab. L. Marques. Delagoa Bay (Penther).

A minute species well illustrated by its author.

Gulella farquhari (Melv. and Pons.), 1895.

1895. *Ennea farquhari* M. and P., A.M.N.H. xvi, p. 478, pl. 18, figs. 3–5. D.F.

Hab. L. Marques. Mount Vengo, Macequece (Cressy).

One of several instances, to be hereinafter mentioned, of a minute species, only known hitherto from the extreme south of the continent, occurring over 1000 miles to the north without an intermediate locality. The Macequece shells are nearer the type than are either of the varieties *advena* Bnp., or *berthae* M. and P., the most noticeable points of difference lying in the somewhat smoother surface and wider, and therefore less obstructed aperture, while the tooth on the outer lip is usually narrower and less inclined to be bifid than in typical *farquhari*; they do not appear to me to be varietally distinct.

Gulella kraussi (Pfr.), 1855.

1856. *Ennea kraussi* Pfr., Novit. Conch. i, p. 73, pl. 20, figs. 14–16. D.F.

Hab. L. MARQUES. Delagoa Bay (in British Museum).

A tablet from the Cuming collection labelled as above bears 3 examples of this species, presumably collected by Plant, as were those on an adjacent tablet, also from the Cuming collection, labelled Natal.

There is nothing inherently improbable in either this or the following species, both prominent Natal forms, extending up the coast to Delagoa Bay, but neither of them has been collected there since the days of Cuming, and it appears questionable whether his locality is correct, or whether the shells may not rather have become accidentally separated from a parcel from Natal.

Gulella wahlbergi (Krauss), 1848.

1848. *Pupa wahlbergi* Krs., Südafr. Moll., p. 80, pl. 5, fig. 5. D.F.

1898. *Ennea transiens* Stur., S.A. Moll., p. 19, pl. 1, fig. 4. D.F.

Hab. L. MARQUES. Delagoa Bay (Plant, in British Museum).

The original figures of *wahlbergi* and *transiens* only differ by the large palatal tooth appearing, in *wahlbergi*, to have the upper cusp more prominent and nearer the surface than the lower one, whereas in *transiens* it is accurately represented, as found in this common Natal species.

However, Dr. Baini Prashad has kindly compared typical examples of *transiens* with the type of *wahlbergi* in the Stuttgart Museum, and writes: "The specimens of *transiens* Stur. do not differ in any way from Krauss' unique type of *wahlbergi*. The outer lip has the big tooth absolutely identical in specimens of *transiens* and *wahlbergi*, and I can see no difference between the two."

Under these circumstances it is evident that Krauss' figure is inaccurate, and Sturany's name must be placed in synonymy.

Gulella cf. *laevigata* (Dhrn.), 1865.

(Plate IV, fig. 4.)

1865. *Ennea laevigata* Dhrn., P.Z.S., p. 232. D.

1881. ,, ,, ,, Smith, P.Z.S., p. 281, pl. 32, fig. 6.* N.F.

1893. ,, *karongana* Smith, P.Z.S., p. 633, pl. 59, fig. 2. D.F.

1899. ,, (*Gulella*) *laevigata* Dhrn., Smith, P.Z.S., p. 580. N.

Hab. L. MARQUES. Maforga Siding, B. and M. Rly. (Mcdowell).

Described from Mumba I., Lake Nyasa (Kirk), this species was recorded by Smith in 1881 from between L. Nyasa and the east coast (Thomson), and in 1899 from Zomba Plateau; Masuku Plateau; Nyika Range, and Mt. Chiradzulu, all in Southern Nyasaland.

In 1881 he wrote: "Like several species of Ennea, this also varies much in size. Those described by Dohrn were $\frac{5}{16} \times \frac{1}{8}$ in., whilst the specimens collected by Mr. Thomson are $\frac{7}{16} \times \frac{3}{16}$ in."

In 1899 he remarked: "Somewhat variable in size and in the development of the upper of the two labral teeth. This in the type is somewhat bifid or tuberculated, as described by Dohrn, whereas in the specimens in the present collection it is simple, sometimes of the same size as the adjacent tooth, but sometimes a trifle larger."

The Maforga shells agree with those last mentioned by Smith from Chiradzulu and Zomba Plateau; the upper labral tooth is perfectly simple, and I doubt whether they are not distinct from Dohrn's species. However, the group of somewhat ordinary, smooth, 5-toothed shells, which includes *laevigata* Dhrn., *quinquedentata* C. Bttg., and *tudes* and *planidens* Mts., is at present in far too deeply involved condition for me to add another name, until it has been possible to inspect large series of the last three species.

The type of *E. karongana* Smith is an exact representative of typical *laevigata*, showing fully the bifidity of the upper labral tooth, and must be relegated to synonymy.

Gulella nepia sp. n.

(Plate IV, fig. 7.)

Shell small, cylindrical, rimate, smooth, glossy, pale olivaceous. Spire produced, sides straight and parallel, apex very obtusely angulate. Whorls 6, nearly flat, gradually increasing, devoid of sculpture save for a few distant, irregular, oblique growth lines; suture simple, shallow. Aperture subquadrate, peristome reflexed, dentition 3-fold: a protruding, incurved, not deeply entering lamella on the extreme surface of the paries at its junction with the outer lip; a small blunt tubercle, without any external depression, slightly within the margin half-way up the outer lip, and an exactly similar tubercle half-way up the columella; callus rather thick.

Long. 5·3, lat. 2·2; apert. alt. 1·3, lat. 1·1; last whorl 2·75 mm.

Hab. L. Marques. Macequece District (Cressy).

A member of the very small group, in which the principal columellar process is situate half-way down the columella instead of at its upper angle. The Kenyan *G. pervitrea* (Preston), perhaps its nearest ally, is an altogether larger species.

Gulella distincta (Melv. and Pons.), 1893.

1893. *Ennea distincta* M. and P., A.M.N.H. xi, p. 22, pl. 3, fig. 10. D.F.

1898. ,, *eximia* ,, ,, i, p. 28, pl. 8, fig. 8. D.F.

Hab. L. Marques (?). Between Barberton and Delagoa Bay (fide M. and P.).

I have recently * shown that *G. distincta*, originally recorded from Middelburg, Transvaal, is identical with *eximia*, originally recorded from the locality mentioned overleaf, the vagueness of which makes it, of course, doubtful whether the species really extends its range into Portuguese territory; it has recently been rediscovered at Barberton.

Family RHYTIDIDAE.

Genus Natalina Pilsbry, 1893.

Natalina wesseliana (Maltzan), 1876.

1876. *Helix caffra* Fér., var. *wesseliana* Maltz., Kob., Jahrb. D. Mal. Ges., iii, p. 149, pl. 5, fig. 1. D.F.

Hab. L. Marques. Rikatla (Junod).

This species, of which the locality was then unknown, was first differentiated as a variety of *caffra* in the words: "differt a typo testa obtecte perforata, fere exumbilicata, anfr. ult. valde depresso. Alt. 56, lat. 48 mm."

In 1903, when illustrating a similar specimen, also from an unknown locality, von Möllendorff wrote that if its finding-place, and its distribution relative to *N. caffra*, were sufficiently known, it would probably be constituted a distinct species instead of a mere variety.

N. wesseliana is now proved to occur as a constant form in the vicinity of Delagoa Bay, while there are no authentic records of *caffra* from near that locality. The shells differ so greatly in form that von Möllendorff's inference seems fully justified.

Natalina caffrula Melv. and Pons., 1898.

1898. *Natalina caffrula* M. and P., A.M.N.H. i, p. 24, pl. 8, fig. 1. D.F.

Hab. L. Marques. Matolla (Penther).

I have been unable to verify the accuracy of this determination.

Natalina kraussi (Pfeiffer), 1846.

1848. *Helix kraussi* Pfr., Krs., Südafr. Moll., p. 77, pl. 4, fig. 24. D.F.
1851. ,, *sturmiana* Pfr., P.Z.S., p. 253. D.
1878. *Macrocystis sturmiana* Pfr., Nomenclator, p. 62. L.
1879. *Ampelita* ,, ,, ,, p. 184. L.

Hab. L. Marques. Delagoa Bay (*sturmiana*, fide Pfeiffer).

The type of *sturmiana*, from the Cuming collection, is in the British Museum. It is from an unknown locality, but in the Nomenclator, where this species is placed in two different genera, it is assigned the locality

* Proc. Mal. Soc. xv, 1922, p. 71.

Delagoa, or Dalagoa, Bay. The type of *sturmiana* agrees almost exactly with authentic examples of *kraussi*, as does Pfeiffer's description of the one with that of the other, and the circumstances under which they were ever separated are inexplicable.

The true home of *kraussi* appears to be in the south of the Cape Province, and it is most unlikely that it occurs in Portuguese East Africa.

Family ZONITIDAE.

Subfamily HELICARIONINAE.

Genus Helicarion Férussac, 1821.

Subgenus gymnarion Pilsbry, 1919.

Helicarion (Gymnarion) nyasanus Smith, 1899.

(Pl. V, figs. 4–8.)

1899. *Helicarion nyasanus* Smith, P.Z.S., p. 582, pl. 33, figs. 9–10. D.F.

Hab. L. Marques. District north of Macequece (Cressy).

The shells of many members of this subfamily resemble each other so closely that it is almost impossible to identify a species by the shell alone. I can find no material difference between a large series from Macequece and the type of *nyasanus*, a species which appears to be widely diffused throughout Southern Nyasaland, so that its extension to Macequece is by no means improbable. However, the animal of the Nyasaland race is unknown, while that from Macequece has been available for dissection; I therefore append a description of the latter's shell in case some future anatomist finds the animals distinct :—

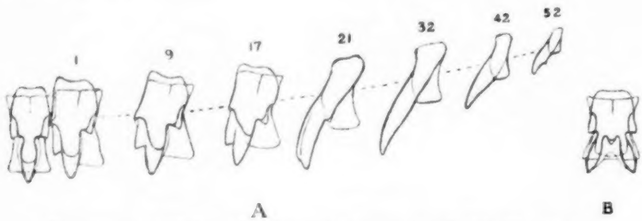
Shell imperforate, subnautiloid, very thin, translucent, dull above, somewhat iridescent beneath, apex light brown, remainder pale olivaceous. Spire flat, apex rounded. Whorls 3, very rapidly increasing, flat above, rather narrowly rounded at the periphery; protoconch, $1\frac{1}{2}$ whorls, engraved with close, microscopic, dotted spiral grooves and showing a few faint transverse wrinkles, remainder rather irregularly sculptured with close, faint striae, following the shape of the outer lip and covered by a very minute microscopical granulation; suture subfiliform. Aperture ovate, peristome thin, simple, straight above until near the periphery, when it recedes sharply; gently curved beneath; columella concave, very weak.

Diam. maj. 17·0, min. 13·3; alt. 7·9; apert. alt. 8·3, lat. 10·5 mm.

The following notes on the anatomy are derived from two examples, neither as large as that described above, but of which one may be considered almost mature.

External features of the animal (Pl. V, figs. 4–6).—The foot-sole is tripartite, owing to the presence of a pair of longitudinal grooves. The foot is truncate at the hind end, and has a caudal mucous pore, over which there projects a short pointed caudal lobe. The foot-fringe is rather broad, and bounded by a conspicuous peripodial groove. Above this there is another peripodial groove, separated from the lower one by a single row of rugae. A rather irregular, median posterior groove is present, and oblique grooves slope down from this to the upper peripodial groove. There is no keel. A well-marked lateral groove runs down on the right side of the head, but the dorsal grooves and the left lateral groove are less conspicuous.

The body-lobes are broad, the left being undivided, and rather narrow shell lobes are also present. The exact form of these pallial lobes will be seen from figures 4 and 5.



TEXT-FIG. 4.—*Helicarion* (*Gymnarion*) *nyasanus* Smith, Macequece.

A. Representative teeth from the radula ; ×250.
B. Central tooth from the radula of another specimen ; ×250.

The animal is of a light colour, except for two dark bands which run for a short distance along the sides of the hind end of the foot. The thin skin over the upper part of the liver and kidney is almost entirely covered with opaque white pigment, and white flecks seem to be scattered over the roof of the lung, and even on the under-side of the kidney. This organ appears to be long and narrow, but unfortunately the pallial organs of the two specimens examined were not sufficiently well preserved for further description.

Digestive system.—The jaw (fig. 8) is very pale brown, and about 2 mm. long. It has a prominent projection in the centre, but is otherwise smooth, excepting for the lines of growth.

The radula of the larger specimen examined (text-fig. 4, A) measures 4·7×2·2 mm. when flattened out. The central and lateral or admedian teeth are tricuspid ; the endocones, however, tend to become united with the mesocones in the outer lateral teeth. The marginal teeth, which are twice as numerous as the laterals, are mostly unicuspid, having single, long, narrow cusps ; but in the three or four transitional teeth next to

the laterals, and in a few of the outer marginals, a more or less vestigial ectocone is present ; and in some of the latter one or two minute additional cusps can also occasionally be seen on the outer side of the mesocone. The rows of teeth curve slightly forwards on each side. The radular formula is $(39+18+1+18+40)\times 114$.

In the smaller specimen the radula measures $4{\cdot}5\times 2$ mm., and its formula is $(39+15+1+15+39)\times 109$. The lateral and marginal teeth are similar to those of the larger specimen, but the centrals are abnormal, having two large cusps and three small ones, as shown in text-fig. 4, B. It is not very uncommon to find similar abnormalities among lateral or marginal teeth, but in such cases it is natural to suppose that two adjacent teeth may have become abnormally united. If, however, the central tooth had become united with the first lateral on one side, we should have expected that this abnormal tooth would have been markedly asymmetrical. As this is not the case, it seems likely that in the present instance we have a mutation in which the central tooth has been almost doubled ; or, if the central tooth be regarded as having been originally formed by the union of two lateral teeth, perhaps we may be dealing with an example of reversion in which this union has been abnormally arrested before becoming complete. That this abnormal tooth is weaker than the others is suggested by the fact that it is missing from several of the rows at the front end of the radula.

The buccal mass is large and muscular, and the radula-sac is completely embedded within it, instead of its hind end projecting as a papilla. The oesophagus leads into a capacious crop (fig. 7). The salivary glands lie on each side of the crop, but are loosely united above it ; they are very large, especially the left one. The nerve-ring surrounds the oesophagus, salivary glands, and buccal retractors, behind the buccal mass. The various ganglia are enclosed in much connective tissue, and are rather closely approximated, the commissures and connectives being short.

Free retractor muscles (fig. 7).—The buccal retractor and the two tentacular retractors are separate almost from their origin. The buccal retractor divides into a right and a left portion, separately innervated, a considerable distance behind the buccal mass. The retractor of the right upper tentacle passes between the penis and the vagina. Another muscle, quite distinct from the last, runs along the right side of the animal to the head. No definite muscle could be found passing from the columella to the foot. The penial retractor arises from the diaphragm.

Reproductive organs (fig. 7).—Unfortunately the reproductive system was not fully developed in either of the specimens examined, but it is evidently of a comparatively simple type. The receptaculum seminis is large and bluntly pointed posteriorly, and is borne on a rather short receptacular duct. The vagina is of no great length, and seems to be without

any accessory organs. The vas deferens becomes slightly convoluted and swollen next to the penis, forming an incipient epiphallus, but no trace of a flagellum could be found. The penis is rather small, but this is probably due to the immaturity of the specimens.

Affinities.—This species appears to belong to the subgenus *Gymnarion* Pilsbry.* It bears a considerable resemblance to *Helicarion gomesianus* Morelet in its radula and in the coloration of the animal, as well as in its reproductive organs being without flagella; but it differs from that species not only in having a more pronounced caudal lobe, but also in lacking an amatorial organ.† According to Thiele, *H. welwitschi* Morelet appears to resemble the present form more closely in its reproductive system, but in that species the marginal teeth of the radula retain distinct ectocones.‡ The other African species of *Helicarion* that have been dissected seem to differ still more from the present species in their anatomy, notwithstanding the general resemblance of their shells.

Genus KERKOPHORUS G.-Austen, 1912.

Kerkophorus poeppigi (Menke), 1846.

1854. *Vitrina poeppigii* Mke., Pfr., Conch. Cab., p. 17, pl. 2, figs. 13–15. D.F.

Hab. L. MARQUES. Rikatla (Junod).

Included in Junod's list of 1899; I have not seen examples from the locality.

Genus GUDEËLLA Preston, 1913.

(= *Thapsiella* Gude, 1911, non Fischer, 1884.)

This genus was founded for numerous small zonitoid species, originally attributed to *Thapsia* Albers, but very much smaller than the type of the latter, *troglodites* Morelet.

Pilsbry (1919) considered that there was not room for both genera, but it is certainly convenient to have a distinct name for the smaller forms, and the fact that I am able to give some details as to the anatomy of *Gudeëlla* furnishes additional cause for preserving the genus-name until the anatomy of the larger species is known.

* Pilsbry: Bull. Amer. Mus. Nat. Hist., vol. xl, 1919, p. 275; Watson: Proc. Malac. Soc., vol. xiv, 1920, p. 112.

† Watson: *ibid.*, pp. 91–96, pl. iii.

‡ Thiele: Deutsch. Zentral-Afrika-Exped. (1907–1908), vol. iii, 1912, pp. 190, 191, 198, text-fig. xii.

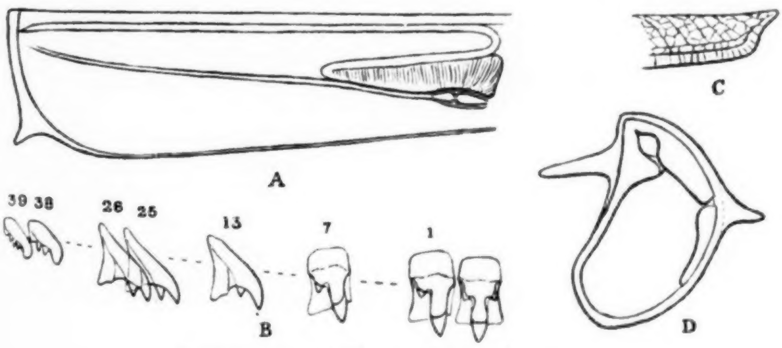
Gudeëlla mixta (Smith), 1899.

1899. *Thapsia mixta* Smith, P.Z.S., p. 582, pl. 33, figs. 13-15. D.F.

Hab. L. MARQUES. Macequece District; Dondo; Mtisherra R. Valley; Zangwe Basin (Cressy); Maforga Siding (Mcdowell).

Described from Mt. Chiradzulu, this widely distributed species appears to extend northwards to Kenya, where it has been collected by Kemp at Rumruti, and westwards to the Belgian Congo, whence I can find no valid grounds for separating from it shells collected by Dyke at Boteke and Leverville.

While very constant in form, it varies considerably in colour, which



TEXT-FIG. 5.—*Gudeëlla mixta* (Smith), Macequece.

A. Roof of mantle-cavity seen from the outside, showing kidney, etc. (slightly diagrammatic); ×8.
B. Representative teeth from the radula; ×600.
C. Hind end of foot seen from the left side; ×10.
D. Mantle-edge seen from the front, showing pallial lobes; ×13.

may be lacteous, corneous, or even bicoloured, and in the strength of its spiral sculpture on both sides, but every intermediate grade seems to exist, so that it is inadvisable to attempt separation. *Zonitoides cupido* M. and P. appears identical with Smith's species and will probably have to be placed in synonymy.

The foot of the animal of *mixta* (text-fig. 5, C) is narrow, and ends posteriorly in a pointed lobe, overhanging the caudal mucous gland, which opens by a vertical slit. Peripodial grooves cut off a rather broad foot-fringe, and the sole is tripartite.

The mantle-edge (text-fig. 5, D) bears a couple of somewhat pointed shell-lobes. The right one is rather narrow, and nearly 1 mm. long in a dead, contracted animal; the left is smaller, and somewhat triangular in form.

Well-developed body-lobes are also present, the left being divided into two distinct, but contiguous, portions.

The hinder end of the foot, the mantle-edge, and the roof of the mantle-cavity are all darkly pigmented. The kidney, on the other hand, is yellow, and therefore stands out conspicuously when the animal is extracted from its shell. This organ (text-fig. 5, A) is rather narrow and about 3 mm. in length, being practically three times as long as the pericardium. The ureter is speckled with dark pigment, and arises from the front end of the kidney, running back along its upper edge and then forwards again beside the rectum to the anus. A single pulmonary vein can be seen passing backwards from the neighbourhood of the respiratory orifice to the heart.

The radula (text-fig. 5, B) measures about $1{\cdot}125 \times {\cdot}6$ mm. when flattened out. The central and lateral teeth are tricuspid. Their mesocones are rather long, projecting considerably beyond the posterior edges of the basal plates. The endocones of the lateral teeth are narrow and inconspicuous, being attached laterally to the mesocones; the ectocones are short, but quite distinct. The basal plates of these teeth have the usual somewhat quadrate form. The marginal teeth are narrow, and about three times as numerous as the laterals. They have narrow bases, and curved bifid cusps, which are composed of the mesocones and the slightly shorter ectocones.* Towards the edges of the radula the teeth become smaller and shorter, their mesocones become blunter, and their ectocones split up into two or three separate small cusps. The transverse rows of teeth trend slightly forwards on each side, forming an obtuse angle in the centre. The radular formula is: $(31+10+1+10+30) \times 77$.

Unfortunately in the only full-grown specimen available the internal organs were in such a bad state of preservation that it is impossible to describe the reproductive system, or to say anything definite about the affinities of this snail, although the character of the pallial lobes suggests that it may possibly be related to the South African forms which Godwin-Austen has placed in the Peltatinae.

Gudeëlla insimulans (Smith), 1899.

1899. *Thapsia insimulans* Smith, Proc. Zool. Soc., p. 583, pl. 33, figs. 16–18. D.F.

Hab. L. MARQUES. Headwaters of R. Inyamkarrara, 25 miles N.W. of Macequece, 4500 ft. (Cressy); Maforga Siding (Mcdowell).

A flatter, more compact little shell than the preceding, but with somewhat similar distribution, as, in addition to the type locality, Mt. Chiradzulu,

* In one of the two radulae examined the ectocone was absent in the 10th, 11th, 12th, and 18th teeth on the left side, a rather interesting abnormality.

it has been collected by C. Harries in the Darugu River valley, Kenya Colony, and is recorded by Germain from the Krebedje District and Tété, in Oubangui.

Genus ZINGIS von Martens, 1878.

Zingis morrumbalensis (Melv. and Pons.), 1894.

1894. *Nanina morrumbalensis* M. and P., A.M.N.H. xiv, p. 90, pl. 1, fig. 1. D.F.

Hab. MOZAMBIQUE. Mt. Morrumbala (type, Layard).

L. MARQUES. District north of Macequece (Cressy).

The type is somewhat immature, for the largest of Cressy's specimens measures: diam. maj. 30·3; min. 25·2; alt. 17·0 mm.

The shell is remarkable for the sculpture of its apex, which shows low radial folds for the first half whorl and is microscopically spirally striate for about the two succeeding ones, while the post-embryonic whorls are very finely and densely granulate, thus acquiring a dull appearance, which is in great contrast to the glossy apex.

The foot of the animal has well-marked peripodial grooves, curving upwards at the extremity. The skin over the mantle-cavity, etc. (in a young specimen), is spotted with dark pigment and opaque white patches. The kidney is not quite so long and narrow as in *Ledoulxia mozambicensis*, but extends for some distance in front of the pericardium. It forms a yellowish band on the outside, which contrasts with a black band immediately above it, marking the course of the primary ureter.

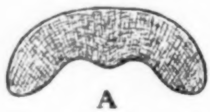
The jaw (text-fig. 6, A) is rather thin, with an obtuse median projection, and is about 3·3 mm. in length. It shows numerous extremely fine lines of growth crossed by equally fine radial striæ.

The radula (text-fig. 6, B) measures about 6·2×3·1 mm., when flattened out. The central and lateral teeth are tricuspid; their mesocones project slightly beyond the posterior edges of the basal plates; the endocones are rather narrow and about half the length of the mesocones, to which they are attached laterally; the ectocones are shorter but quite separate from the mesocones. The outline of the basal plates is strongly convex on the inner side and concave on the outer. The marginal teeth are more numerous and more closely crowded. They have narrow curved bases, and rather long bifid cusps, composed of a long curved mesocone and a smaller ectocone borne on its outer side. Towards the edges of the radula the teeth diminish in size, the points of the mesocones become rounded, and in a few of the outer marginals the ectocone becomes split into two, or even three, distinct small cusps. The last four or five teeth on each side are quite vestigial, suggesting that this species may have been evolved from one in which the

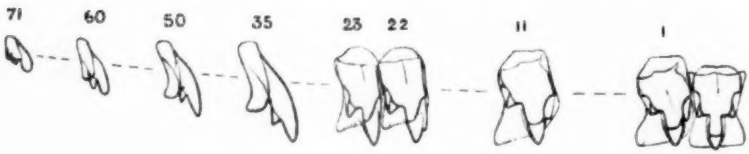
marginal teeth were even more numerous. The rows of teeth trend slightly forwards on each side. The radular formula is : $(54+22+1+22+53)\times 128$.

The radula of a young specimen measures about $4{\cdot}8\times 2{\cdot}1$ mm., and differs slightly from that of the adult in that the ectocones of the marginal teeth are a little longer. Its formula is : $(51+18+1+18+49)\times 132$.

The remainder of the anatomy of this species is unfortunately unknown, the specimens examined being in a very bad state of preservation ; but the characters of the foot, jaw, and radula prove that it is rightly assigned to the Zonitidae, and that Möllendorff was wrong in transferring it in 1903 to the Rhytididae. It cannot be retained in the defunct *Nanina*,



A



B

TEXT-FIG. 6.—*Zingis morrumbalensis* (M. and P.), Macequece.
A. Jaw ; $\times 9$.
B. Representative teeth from the radula ; $\times 225$.

but it is somewhat doubtful in what genus to place it. The shell, however, is very near akin to that of the common Nyasaland *Helix whytei* of Smith, which that author subsequently attributed to *Zingis* ; it may be well, therefore, to arrange the two species next each other in that genus until more is known of their anatomy.

SUBFAMILY LEDOULXIINAE.

Genus LEDOULXIA Bgt., 1885.

Ledoulxia bloyeti (Bgt.), 1889.

1889. *Trochonanina bloyeti* Bgt., Moll. de l'Afr. équat., p. 21, pl. 2, figs. 10–12. D.F.

Hab. L. MARQUES. Mtisherra R. Valley ; Zangwe Basin (Cressy).

Described from Kondoa, Usambara, and unknown hitherto from any

other locality except Zanzibar. Bourguignat mentions the striae as being spotted with white about the suture, which rather suggests a worn shell; Cressy's examples do not present this feature, but agree so closely in all other respects with the original figure and description that there can be no doubt as to the accuracy of their determination. The shell is remarkable for its flattened spire, with convex sides, and is easily recognisable.

Ledoulxia jenynsi (Pfr.), 1845.

1845. *Helix jenynsi* Pfr., P.Z.S., p. 131. D.

Hab. MOZAMBIQUE. Querimba I. (Peters).

L. MARQUES. Tette (Peters). Zangwe Basin (Cressy).

The well-known white-shelled species with brown band at the periphery; its rediscovery in the Zangwe Basin tends to confirm the accuracy of von Martens' doubtful record of Tette.

Ledoulxia mozambicensis (Pfr.), 1855.

(Plate VIII, figs. 1–4.)

1855. *Helix mozambicensis* Pfr., P.Z.S., p. 91, pl. 31, fig. 9. D.F.

Hab. MOZAMBIQUE (Stuhlmann; Gibbons; Frey).

L. MARQUES. Tette (type, Peters); Movene (Penther); Wanetsi R., Magude District (Bell Marley); Antioko; under stones in the Lebombo Mountains (Junod); Zangwe Basin; Mtisherra R. Valley (Cressy).

In view of some confusion over this species, for which Bourguignat is mainly responsible, it is necessary to recognise the fact that it was founded on only two shells, which are available for reference in the British Museum. One of these is very young, and the other, Pfeiffer's type, is considerably weathered and by no means full grown, measuring $12 \times 10\frac{1}{2}$ mm. in diameter and $6\frac{1}{2}$ mm. in height.

It is not, however, one of a race of small shells, as Bourguignat has written, but merely an immature example of the larger race which appears to have been rightly accepted by Smith, von Martens, Pilsbry, and Germain, to mention only four leading authorities of different nations, as representing Pfeiffer's species. The series from Lebombo Mountains, of which the anatomy is described below, appear to agree with the type in every respect, except that the aperture is comparatively a little more laterally compressed and slightly greater in altitude. It is therefore the more remarkable that Semper's account of the anatomy of specimens from the type locality shows some important points of difference from that of Watson, who reports as follows:—

Semper * and Godwin-Austen † have already partly described the

* Reis. Arch. Philipp., vol. ii. (3), 1870, p. 42, pl. iii, fig. 5, pl. vi, fig. 15.

† Proc. Malac. Soc., vol. i, 1895, pp. 281, 282, pl. xix, figs. 1–1e.

anatomy of specimens said to belong to this species, the German author's examples having been collected at Tette, the type locality; but their descriptions and figures do not altogether agree either with each other or with the anatomy of specimens collected by Junod in the Lebombo Mountains. It therefore seems advisable to give a brief account of the more important organs of the animals from this locality.

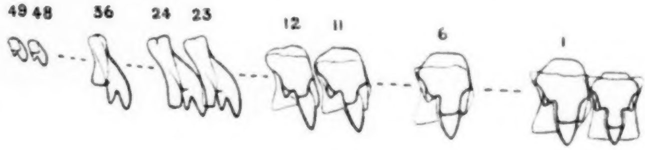
Foot.—The foot-sole is conspicuously tripartite by a pair of deep longitudinal grooves, the median area being of about the same width as the lateral areas towards the anterior end of the foot, but becoming narrower posteriorly. A large caudal mucous pore is present, extending as a vertical slit down to the extremity of the sole, and thus differing from Godwin-Austen's description and fig. 1*a*. The mucous pore is overhung by a pointed, pigmented, caudal process, which was abnormally bifurcated in one of the specimens examined (see Pl. VIII, fig. 2). In the other specimens it was intermediate in length between the long appendage figured by Godwin-Austen and the very short one shown in von Marten's drawings.* The foot-fringe is bounded above by a well-defined peripodial groove on each side, which bends up at the hind end in front of the mucous pore, and then runs along the side of the caudal process in normal specimens. Just above the peripodial groove a second horizontal groove runs along each side of the foot, and this receives oblique grooves, of which the more posterior arise from a median longitudinal groove on the top of the hinder part of the foot. This part of the foot is laterally compressed, but it bears no keel, such as Godwin-Austen mentions.

Mantle and pallial organs.—The mantle-edge bears the usual right and left body-lobes, the left being divided into two separate portions having the form shown in text-fig. 7, B. No shell-lobes are present. The thin skin covering the mantle-cavity and upper whorls is beautifully mottled with dark pigment and opaque white patches after the manner shown in Pl. VIII, fig. 1. The roof of the mantle-cavity or lung does not display a marked pulmonary reticulation, but numerous slender veins can be distinguished in addition to the large pulmonary vein which runs to the heart from the neighbourhood of the respiratory opening (text-fig. 7, B). Semper states that the kidney is short. In the specimens from the Lebombo Mountains it is long and narrow, being about 9 mm. long, that is to say about half the length of the mantle-cavity, with an average breadth of scarcely more than 1 mm. The ureter arises from its extreme front end, passes backwards along its upper edge, and then forwards immediately beneath the rectum as far as the anus, the secondary ureter being closed throughout.

Central nervous system.—The nerve ring (Pl. VIII, fig. 4) is small, and

* Deutsch-Ost-Afrika, vol. iv, 1897, pl. i, figs. 8, 8*a*, 8*b*.

surrounds the oesophagus, salivary ducts, and buccal retractor, being too narrow to allow the buccal mass to be retracted through it. The cerebral ganglia are united by a thick cerebral commissure, and each has a very prominent lateral accessory lobe. The right cerebral ganglion gives rise to the large penial nerve, in addition to the usual paired nerves. The buccal ganglia are rather obscurely bilobed. The cerebro-pedal and cerebro-pleural connectives are short, being considerably shorter than the cerebro-buccal connectives. The pedal ganglia bear the otocysts on their upper



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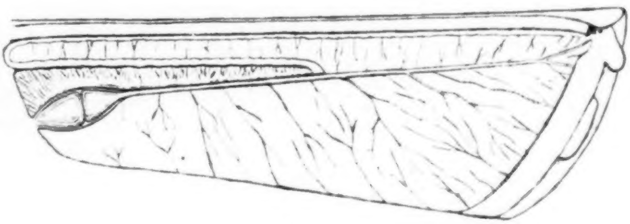


B

TEXT-FIG. 7.—*Ledoulxia mozambicensis* (Pfr.), Lebombo Mountains.

A. Representative teeth from the radula ; ×350.
B. Roof of mantle-cavity seen from within, showing kidney, etc. (slightly diagrammatic) ; ×5.

surfaces ; their ventral surfaces seem to be obscurely divided by slight transverse grooves into about three segments, of which the anterior pair is much the largest. The visceral loop is very asymmetrical, and its ganglia are all distinct from one another, though closely aggregated. The abdominal ganglion is obliquely elongated behind the large right parietal ganglion.

Digestive system.—The jaw measures about 1·5 mm. in length. It is rather thin and practically smooth, with a large median projection.

The radula (text-fig. 7, A) measures about 3·3 × 1·5 mm. when flattened out. The central and lateral teeth are tricuspid, the central being slightly smaller than the laterals. The endocones of the lateral teeth are not very conspicuous, being rather narrow and attached laterally to the stout

mesocones. The basal plates of these teeth have the usual somewhat quadrate form. The marginal teeth are more than three times as numerous as the laterals, and gradually decrease in size towards the edges of the radula. They have narrow basal plates, and strongly curved bifid cusps, formed of the mesocones and the somewhat shorter ectocones. The rows of teeth trend slightly forwards on each side of the middle line. The radular formula of the specimen figured is: $(42+11+1+11+40)\times 148$. That of another example is: $(35+11+1+11+36)\times 135$.

Semper's figure shows no endocones on the lateral teeth, and not even an ectocone on the tenth tooth, which may have been abnormal in the radula that he examined. He does not depict the marginal teeth, but states that they have typical bifid cusps. Godwin-Austen also shows no endocones on the lateral teeth, which he depicts as smaller than the central tooth and far narrower than they are in the specimens from the Lebombo Mountains. Moreover, he figures the marginal teeth as having very much smaller ectocones. If Godwin-Austen's figures are accurate there can be little doubt that the form he studied is specifically distinct from the one now described.

The crop is narrow, and the salivary glands are united above it.

Free retractor muscles.—The columellar muscle divides almost at its origin into four main branches: a powerful buccal retractor, which lies above the other muscles and is bifurcated in front; the right and left tentacular retractors, each of which gives off a stout branch to the anterior end of the foot before dividing into the retractors of the upper and lower tentacles; and a broad ventral muscle to the posterior part of the foot. The retractor of the right upper tentacle passes between the vagina and the penis. The penial retractor arises from the posterior end of the diaphragm, and is inserted in the epiphallus.

Reproductive system (Pl. VIII, fig. 3).—The hermaphrodite gland is embedded in the posterior division of the liver. The hermaphrodite duct is less swollen and convoluted than is often the case; it bears a small oval vesicula seminalis at its junction with the albumen gland. The common duct is of the usual form, as may be seen from the figure. The free oviduct is of moderate length, longer than in Godwin-Austen's figure; the vagina is short; and both are rather narrow. The genital atrium is small, and no dart-sac is present. The receptacular duct has muscular walls and is nearly twice the length of the free oviduct; posteriorly it merges gradually into the club-shaped receptaculum seminis or spermatheca, which has much thinner walls and lies against the common duct. Semper's figure shows an oval spermatheca, with a longer and more slender duct, swollen at its junction with the vagina. Godwin-Austen shows an organ a little less unlike that just described.

The slender vas deferens runs forward beside the female duct almost to the genital atrium; it then bends round towards the penis and immediately enlarges to form the somewhat broader and extremely long epiphallus. At the junction of the vas deferens and the epiphallus the latter organ bears a minute oval calciferous sac or flagellum, so small that it might easily escape notice if it were not for its opaque white colour. The epiphallus passes backwards for nearly 6 mm. and then bends forwards again, giving off at the angle a rather long slender caecum. The penial retractor unites with the epiphallus just in front of the origin of this caecum, which seems also to be attached to the retractor at two points near its anterior end. The epiphallus then passes forwards to unite with the posterior end of the penis, which is nearly 4 mm. long and somewhat swollen, but has a slight constriction in the middle. Its walls are longitudinally folded within, and lined with very minute papillae. Towards its posterior end the penis bears on one side an oval glandular appendage, enclosed in a very thin sheath which surrounds also the extremity of the penis and the anterior end of the epiphallus. (This sheath is not shown in the figure.)

Semper and Godwin-Austen both figure a somewhat similar penis, but the German author states, possibly in error, that there is a "caecum musculi retractoris penis," in addition to the glandular appendage, the long caecum, and the very small calciferous sac. Godwin-Austen's drawings depict a far larger calciferous sac than that found in the animals from the Lebombo Mountains. Pilsbry's figures of the reproductive system of *Ledoulxia mesogaea* (Mts.) and *L. lessensis* Pilsbry * show that these species have the same type of genital organs as that described above, although they differ in detail.

The shells from the Mtisherra R. Valley differ rather noticeably from type. The whorls are tighter coiled, there being about three-quarters of a whorl more in a diameter of 12 mm. than in *mozambicensis*, and the sides of the spire are a little concave near the apex, so that the 2 apical whorls are somewhat mammillate, whereas in *mozambicensis* the sides are convex; the transverse striation also appears very slightly stronger than that of *mozambicensis*.

Ledoulxia albopicta (Mts.), 1869.

1869. *Nanina mossambicensis* Pfr., var. *albopicta* Mts., von der Decken's Reisen, iii, p. 56, pl. 1, fig. 2. D.F.

1885. *Trochonanina anceyi* Bgt., Hélixarionidées, p. 9. D.

1897. „ *jenynsi* Pfr., var. *subjenynsi* Ancey, Mts., D.-O.-A., iv, p. 49. D.

Hab. Mozambique (in coll. Ancey).

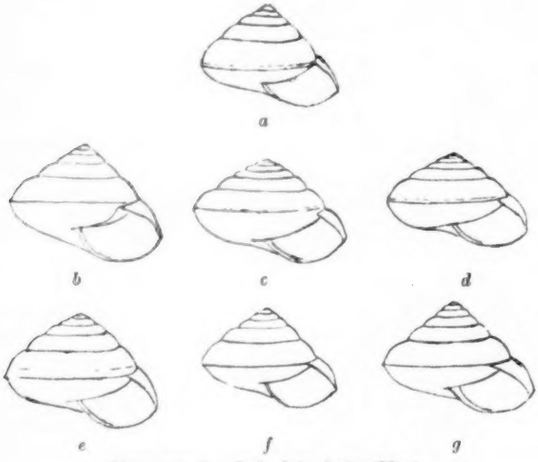
L. Marques. Tette (Peters).

* Bull. Amer. Mus. Nat. Hist., vol. xl, 1919, p. 246, fig. 111, p. 249, fig. 114.

I am not acquainted with authentic examples of von Martens' species, but the German author himself placed *anceyi* in the synonymy of *albopicta*, while *subjenynsi*, as represented in Ancey's collection, is identical with *anceyi*; it is a well-known species, remarkable for its brown and white mottling, quite distinct from *jenynsi* or *mozambicensis*.

Ledoulxia elatior (Mts.), 1866.

1866. *Trochomorpha? mossambicensis* Pfr., var. *elatior* Mts., Mal. Blätt. xiii, p. 92. D.



TEXT-FIG. 8.—*Ledoulxia elatior* (Mts.).
Profile of shells from various localities.
(All figures slightly enlarged.)

a, Mtisherra R. Valley.
b, Bongo.
c, Itschongove.
d, Pangani.
e, Undussuma.
f, Langenberg.
g, Djur Mai.

1869. *Helix mozambicensis*, var. *elatior* Mts., Pfr., Novit. Conch. iii, p. 500, pl. 108, figs. 4–6. D.F.

Hab. L. MARQUES. Itschongove (Schenck); Mtisherra R. Valley (Cressy).

I am greatly indebted to Dr. J. Thiele, of the Berlin Museum, for the accompanying text-figs. 8*a*–8*g*, and remarks about this dubious species, which are so much to the point that I cannot do better than publish them in full.

"Under the name of *H. mozambicensis*, var. *elatior*, von Martens designated several shells from different localities, which I have drawn by the side of yours from the Mtisherra R. Valley. That from Bongo, Abyssinia, must be regarded as typical; below it is placed the shell figured by von

Martens. That from Langenburg differs through having less swollen whorls. All the shells figured are somewhat different from one another; it appears to me that the material is not extensive enough to decide whether they are varieties, or only local forms, of a single species, or, in part, distinct species. The embryonal sculpture is not always recognisable, since the shells are somewhat weathered, as is the case in that from Bongo; in some it consists of fine spiral striation."

It is clear from the foregoing that not much can be done towards the elucidation of this species until further topo-types from Bongo, in better condition, are available for examination. If Cressy's shells are correctly assigned, *L. elatior* is certainly quite specifically distinct from *mozambicensis*, having weaker sculpture and nearly always a higher spire. The first 2 whorls are rather strongly, closely, microscopically transversely wrinkled and extremely finely, faintly spirally striate; remainder very closely, finely, faintly, transversely striate, the striae being finer, fainter, and closer than in *mozambicensis*.

Subfamily SITALINAE.

Genus Sitala H. Adams, 1865.

Sitala diaphana Conn., 1922.

(Plate IV, fig. 8.)

1922. *Sitala diaphana* Conn., A.M.N.H. x, p. 116. D.

Hab. L. Marques. District N. of Macequece (Cressy).

An extremely thin and fragile shell, unlike anything known to me; the largest example seen measures 4·7 mm. in maximum diameter, but is too much worn to show the spiral sculpture which is characteristic of fresher specimens.

Genus Kaliella Blanford, 1863.

Kaliella barrakporensis (Pfr.), 1852.

1854. *Helix barrakporensis* Pfr., Conch. Cab., p. 415, pl. 147 (1853), figs. 20–22. D.F.

1882. *Kaliella sigurensis* G.-Aust., L. and F. W. Moll. India, i, p. 5, pl. 1, fig. 11. D.F.

1912. *Kaliella sigurensis* G.-Aust., Conn., Ann. S. Afr. Mus. xi, p. 117. N.

1914. „ *barrakporensis* Pfr. (=*sigurensis*, G.-Aust.), Dautz. and Germ., Rev. Zool. Afr. iv, p. 17.

Hab. L. Marques. District north of Macequece (Cressy).

The type of *K. sigurensis* has not been available for examination, but examples from Pretoria, identified by Godwin-Austen as that species,

certainly appear to be inseparable from *barrakporensis*, and I think that Dautzenberg and Germain's synonymy may be accepted as correct.

The Macequece specimens agree with those from Pretoria; they are very closely, finely transversely striate above, and clearly, rather closely radiate, and with rather close engraved microscopic spiral grooves beneath.

FAMILY UROCYCLIDAE.

Genus UROCYCLUS Gray, 1864.

Urocyclus fasciatus (Mts.), 1879.

1879. *Aspidoporus fasciatus* Mts., Monatsb. Akad. Wiss. Berlin, p. 736. D.

Hab. MOZAMBIQUE. Quilimane (Peters).

L. MARQUES. Andrada (Vasse).

Urocyclus flavescens (Keferstein), 1866.

1866. *Parmarion flavescens* Kfstn., Mal. Blätt. xiii, p. 70, pl. 2, figs. 1–8. D.F.A.R.

Hab. MOZAMBIQUE. Quilimane (Peters).

L. MARQUES. Inhambane; Mungurumbe (Peters); Delagoa Bay (Spencer); Mt. Vumba, 4300 ft. (Vasse).

The record of this species by Gibbons, 1879, should be expunged from my Reference List, as it refers to *Kirkia gibbonsi* (v. infra).

Urocyclus kirki Gray, 1864.

1864. *Urocyclus kirkii* Gray, P.Z.S., p. 251. D.F.

Hab. MOZAMBIQUE. Near the mouth of the Zambesi (Kirk).

L. MARQUES. Delagoa Bay; Inhambane (fide Sturany); Andrada (Vasse).

Genus KIRKIA Pollonera, 1909.

Kirkia gibbonsi nom. nov.

1879. *Urocyclus flavescens* Kfstn., Gibb., Journ. of Conch. ii, p. 138. D.

1879. ,, *kirkii* (?) Gray, Binn., Bull. Mus. Comp. Zool. v, p. 333, pl. 2, fig. C, D. D.R.

1884. *Urocyclus fasciatus* (?) Mts., Heynem., Jahrb. D. Mal. Ges. xi, p. 9, pl. 1, fig. 5. N.R.

1909. *Kirkia flavescens* Gibb., Pollon., Il Ruwenzori, p. 192. N.

Hab. MOZAMBIQUE (Gibbons).

var. *pallida* Gibb., 1879.

1879. *Urocyclus flavescens* Kfstn., var. *pallida* Gibb., Journ. of Conch. ii, p. 138. D.

Hab. Mozambique (Gibbons).

When Pollonera created a new genus for the slug which Gibbons misidentified as *Urocyclus flavescens* Kfstn., he retained the name *flavescens* for the species, merely transferring its authorship to Gibbons, on the ground that, as it now belongs to a different genus, the name is valid. As, however, Gibbons described the species as an *Urocyclus*, Pollonera's action is contrary to the rules of nomenclature, and a new name is required for his genotype. It may be suggested that Gibbons' own name of *pallida* should be applied to the species, of which, in that case, his *U. flavescens* would become a darker coloured variety, but as it is the radula of the latter that has been published, and there is no certainty that *pallida* is even conspecific, it seems wiser to adopt my procedure.

Family ENDODONTIDAE.

Subfamily ENDODONTINAE.

Genus Endodonta Albers, 1860.

Subgenus Afrodonta M. and P., 1908.

Endodonta (*Afrodonta*) *novemlamellaris* Burnup, 1912.

1912. *Endondonta* (*Afrodonta*) *novemlamellaris* Bnp., Ann. Natal Mus. ii, p. 341, pl. 24, figs. 11–13. D.F.

Hab. L. Marques. Mt. Vengo, 5500 ft. (Cressy).

This species had only been collected previously in the Cape Province, but I am now able to record a locality in Natal, Ntimbankulu (Burnup).

Some notes on the anatomy follow :—

The foot has well-marked peripodial grooves, and is of a light colour. The tentacles are nearly black, and show clearly through the overlying tissues when they are contracted. The roof of the mantle-cavity is pale and translucent.

The kidney (text-fig. 9, A) is rather broad and about twice the length of the pericardium. It extends a little further back than usual, and the posterior part stretches upwards to the rectum, though the upper prolongation between the rectum and the secondary ureter is not developed in this species as it is in *Trach. pura* Conn. The ureter arises from the front end of the kidney and is reflexed in the usual manner.

The jaw measures about $1{\cdot}1 \times {\cdot}18$ mm. It is very thin, and is crossed by about twelve narrow vertical folds.

The radula (text-fig. 9, B) measures ${\cdot}38 \times {\cdot}1$ mm. when flattened out.

The individual teeth are extremely small. The central teeth are tricuspid, but their mesocones are only about half the length of the quadrate basal plates, and their ectocones are scarcely half the length of the mesocones. In the inner lateral teeth the mesocones are of about the same size as in the central teeth, but they are situated much nearer the inner than the outer sides of the teeth. The endocones of the lateral teeth are very small; the ectocones, on the other hand, are slightly larger than those of the central teeth. An extremely minute additional cusp is inserted between the mesocone and the ectocone of each of the lateral teeth. The basal plates of these teeth are slightly oblique, though of about the same length as in the central teeth. In the transitional teeth the basal plates begin to shorten, and the three principal cusps become longer and more pointed. The marginal teeth are somewhat pectinate in form, the bases being shorter and the

A

B

TEXT-FIG. 9.—*Endodonta* (*Afrodonta*) *novemlamellaris* Burnup, Vengo Mountain.

A. Kidney, heart, etc., seen from the outside (slightly diagrammatic); $\times 17$.
B. Half of a transverse row of teeth from the radula; $\times 1600$.

cusps sharply pointed and more numerous, owing to the ectocones having split up into three or four small cusps and the endocones often into two. In these teeth the endocones are better developed than in the laterals, but the mesocones are still the longest of the cusps. The transverse rows of teeth trend very slightly forwards on each side in the region of the lateral teeth, and more decidedly in that of the marginal teeth. The radular formula is: $(7+8+1+8+6)\times 100$.

The radula of this species is specially interesting because, although the marginal teeth scarcely differ from the type most usually found in the Endodontinae, the central and lateral teeth in several features show some approach to the type found in the Punctinae, and thus suggest how this rather peculiar type of radula may have been evolved (compare text-fig. 9, B with text-figs. 15 and 16, B). In Godwin-Austen's figure of the radula of *Endodonta* (*Afrodonta*) *bilamellaris* (M. and P.),* the central and lateral teeth are depicted as of the ordinary type, such as we find in *Trach. vengoensis* Conn. (text-fig. 14).

* Ann. Mag. Nat. Hist., ser. 8, vol. i, 1908, pl. viii, fig. 2*b*.

Genus Trachycystis Pilsbry, 1893.

Trachycystis aenea (Krauss), 1848.

1848. *Helix aenea* Krs., Südafr. Moll., p. 75, pl. 4, fig. 18. D.F.
1892. „ *(Pella) burnupi* M. and P., A.M.N.H. x, p. 239, pl. 13, fig. 6. D.F.

Hab. L. Marques. Cape Delagoa (Plant); Delagoa Bay (Connolly).

The widely distributed Natalian species so well known as *T. burnupi* (M. and P.) can unfortunately no longer retain that name, typical examples from Pietermaritzburg having been compared with the type of *T. aenea* (Krs.), and found to be absolutely identical.

It is interesting to note that all the shells collected at Delagoa Bay, both by Plant and the present writer, have a slightly, but noticeably, more narrow umbilicus than is usually found in specimens from Natal, which suggests that they may have bred true to this small peculiarity for over fifty years.

Trachycystis ambigua Conn., 1922.

(Plate IV, fig. 9.)

1922. *Trachycystis ambigua* Conn., A.M.N.H. x, p. 116. D.

Hab. L. Marques. Headwaters of R. Inyamkarrara, 25 miles N.W. of Macequece (type, Cressy); Lebombo Marsh, Rikatla (Junod).

Nyasaland. Mt. Chiradzulu (Johnston).

S. Rhodesia. Vumbu Range, near Umtali, 7000 ft. (Arnold).

The largest specimen seen is 4·85 mm. in maximum diameter.

A member of the puzzling group which includes *inclara* Morel., *coxi* Preston, and *shilwaneensis* Conn., from the last of which, its nearest ally, it differs in having a very slightly lower spire and narrower whorls, in the spiral striae being a little weaker above and further apart on the base, and in being almost imperforate, whereas in *shilwaneensis* there is a very minute, but clear, umbilicus.

Trachycystis sericea Conn., 1922.

(Plate IV, fig. 10.)

1922. *Trachycystis sericea* Conn., A.M.N.H. x, p. 116. D.

Hab. L. Marques. District 16 miles N. of Macequece, 4500 ft. (Cressy).

S. Rhodesia. Six miles from Penhalonga, 6000 ft. (Miss Grey).

Perhaps nearest to *T. aulacophora* (Ancey) from which it chiefly differs in its deeper suture and more silky appearance; its perforation is much narrower than that of *T. rivularis* (Krs.) or *T. ordinaria* M. and P.

Trachycystis cressyi sp. n.

(Plate IV, fig. 11.)

Shell of moderate size, depressed globose, narrowly umbilicate, thin, somewhat hairy, transparent, corneous, yellow-brown. Spire but little raised, though each whorl is clearly visible in profile above the next; apex obtuse. Whorls 4, regularly increasing, shouldered at the periphery, which is situate well above the median line; the first 1¼ microscopically punctate, after which the sculpture consists of rather distant, oblique, transverse costulae, increasing in distance on the later whorls, the intervals between them being filled with close, very faint, regular transverse, and equally faint and close spiral striae; the costulae are sparsely furnished on both sides of the shell with irregular, very deciduous, curved spiny hairs; suture simple, well defined. Aperture ¾-lunate, peristome simple, acute; columella weak and concave, margin narrowly reflexed, leaving open the narrow, but deep umbilicus.

Diam. maj. 5·1, min. 4·5; alt. 3·5; apert. alt. 2·2, lat. 2·5 mm.

Hab. L. Marques. District N. of Macequece (type, Cressy).

S. Rhodesia. Six miles from Penhalonga (Miss Grey).

A smaller form than *T. fuscocornea* Smith, or any of the hairy South African *Trachycystes*, while the striation is stronger, the umbilicus narrower, and the hairs fewer than in *T. fusco-olivacea* Smith.

Trachycystis fossula sp. n.

(Plate IV, fig. 12.)

Shell small, depressed orbicular, umbilicate, thin, silky, pale corneous. Spire and apex almost flat. Whorls 4½, moderately convex, gradually and regularly increasing, rounded at the periphery, the first 1¼ punctately microscopically corrugate, remainder sculptured all over with close, regular, straight, hardly oblique, transverse costulae, with about 4 microscopic transverse striae in the intervals; suture simple, canaliculate. Aperture ¾-lunate, hardly descending at the base, peristome simple, acute; outer lip almost straight in profile, columella short and concave, margin not reflexed, umbilicus rather narrow, but deep.

Diam. maj. 3·3, min. 3·0; alt. 2·0; apert. alt. 1·5, lat. 1·4 mm.

Hab. L. Marques. Mount Vengo, 5500 ft. (Cressy).

More widely umbilicate than *T. sericea*, and differing from other small species, such as *T. rivularis* (Krs.) and *ordinaria* M. and P., which resemble it superficially, in its sculpture, which is almost at right angles to the suture instead of being considerably oblique, and recalls the larger *T. charybdis* (Bs.) rather than any of the smaller forms.

Trachycystis mcdowelli Conn., 1922.

(Plate IV, fig. 13.)

1922. *Trachycystis mcdowelli* Conn., A.M.N.H. x, p. 117. D.

Hab. L. MARQUES. Maforga Siding. B. and M. Rly. (Mcdowell).

A particularly neat, close-coiled little species, not closely resembling any known to me from Africa.

Trachycystis rudicostata Conn., 1922.

1922. *Trachycystis rudicostata* Conn., A.M.N.H. x, p. 117. D.

Hab. L. MARQUES. Mt. Vengo (Cressy).

Type in British Museum.

TEXT-FIG. 10.—*Trachycystis rudicostata* Conn., Dargle.
Three individuals, measuring respectively 1·91, 2·02, and 1·8 mm. in maximum diameter, the last, lowest in text-fig., being the type.

This species has been known for many years, and I have retained the unpublished name originally suggested for it by Melvill and Ponsonby. It is widely distributed throughout Natal, having been collected at Dargle (type); Inhluzani Mountain; Nottingham Road; Howick; Hilton Road; Edendale; Pietermaritzburg; Ntimbankulu Hill, Mid-Illovo District; Van Reenen's Pass, Drakensberg (Burnup), and Majuba (Connolly).

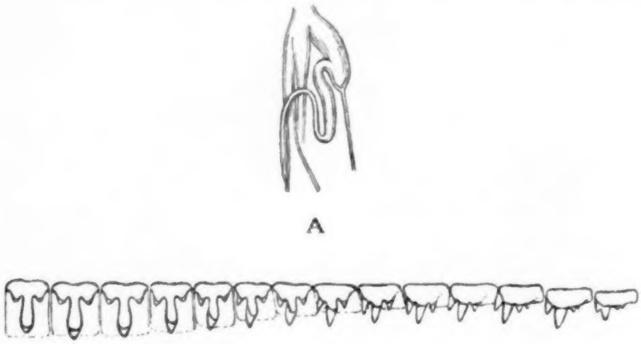
Almost the only difference between it and *T. lamellifera* (Smith) is that the latter appears to be quite destitute of the microscopic spiral striation which is so prominent in *rudicostata*.

The following notes on the animal are taken chiefly from specimens

found at Ntimbankulu, Natal, for which the writer is indebted to Mr. H. C. Burnup of Pietermaritzburg.

The foot has well-marked peripodial grooves. The thin skin of the mantle and visceral hump appears to be unpigmented, but the white posterior aorta stands out conspicuously on the dark liver of the upper whorls.

The radula of a specimen from Ntimbankulu (text-fig. 11, B) measures about $\cdot52 \times \cdot155$ mm. when flattened out. The central and lateral teeth are tricuspid with quadrate bases, the inner lateral teeth being almost symmetrical and closely resembling the central teeth. Their mesocones



A

B

Text-fig. 11.—*Trachycystis rudicostata* Conn., Ntimbankulu, Natal.
A. Anterior part of reproductive system; $\times 25$.
B. Half of a transverse row of teeth from the radula; $\times 1200$.

are long and rather narrow, although the cutting points are comparatively short; the ectocones and endocones are rather small. The marginal teeth are more asymmetrical, with broader, shorter bases, and their endocones and mesocones have longer points. The ectocones become split into two very small cusps on the outer marginal teeth. The transverse rows of teeth are straight in the middle, but tend to curve slightly forwards in the region of the inner marginal teeth. The radular formula is: $(7+6+1+6+7) \times 80$.

The radula of a specimen from Vengo Mountain is very similar, although the teeth are very slightly smaller, there being 97 transverse rows instead of 80, notwithstanding that the radula is of about the same length as in the specimen from Natal.

It will be seen that the radula of this species is of the same general type that is found in the larger species of *Trachycystis*.

The jaw of the specimen from Vengo Mountain measures about $\cdot 16 \times \cdot 02$ mm. It is very thin, but seems to be crossed by about ten or twelve weak vertical folds.

The anterior part of the reproductive system of a specimen from Ntimbankulu is shown in text-fig. 11, A. The free oviduct is long and rather narrow; the vagina, on the other hand, is very short; the receptacular duct becomes enlarged anteriorly towards its junction with the vagina. The vas deferens runs forward about half-way along the free oviduct, and then bends back again to enter the posterior end of the well-marked epiphallus. This organ extends forwards for about ½ mm., and then enters laterally into the penis or penis-sheath, which is also about ½ mm. long and rather broad, with the penial retractor inserted in its posterior end.

Trachycystis soror Conn., 1922.

(Plate IV, fig. 14.)

1922. *Trachycystis soror* Conn., A.M.N.H. x, p. 118. D.

Hab. L. Marques. Mount Vengo, 5500 ft. (Cressy).

Another minute species, which might at first sight be mistaken for *T. rudicostata*, but is easily distinguishable under a microscope on account of its apical sculpture being devoid of spiral striation.

The foot of the animal is of a light colour, and has well-marked peripodial grooves. The tentacles are darkly pigmented, and show clearly through the overlying tissues when they are retracted. The roof of the mantle-cavity is unpigmented and translucent.

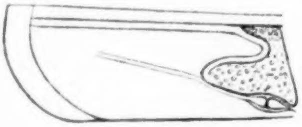
The kidney (text-fig. 12, A) is fully twice the length of the pericardium, and is rather broad, extending upwards to the rectum, where it runs forward for a short distance between the rectum and the beginning of the secondary ureter. Numerous concretions occur in the kidney, especially in its upper part, where some of them attain a diameter of ·017 mm. The ureter is of the reflexed type generally found in the Sigmurethra.

The jaw measures about $\cdot 14 \times \cdot 025$ mm., and is slightly curved. It is very thin, but shows about eleven weak vertical folds.

The radula (text-fig. 12, B) measures $\cdot 4 \times \cdot 13$ mm. when flattened out. The central and lateral teeth are tricuspid, with nearly square basal plates, the inner laterals closely resembling the central teeth. Their mesocones are rather long, reaching the posterior edges of the basal plates; their ectocones and endocones are short. In the marginal teeth the basal plates are much shorter, the mesocones and endocones have longer cutting points, and the ectocones become divided into two or even three small cusps. The transverse rows of teeth are straight in the middle, but tend to curve forwards in the region of the marginal teeth. The following are the

radular formulae of the two specimens examined: $(5+5+1+5+6)\times 82$, $(6+5+1+5+5)\times 80$.

The radula of this species differs from that of *Trachycystis rudicostata* in the teeth being shorter and relatively broader, and in there being fewer of them in each transverse row. These differences, however, are not very



A

B

TEXT-FIG. 12.—*Trachycystis soror* Conn., Vengo Mountain.

A. Roof of mantle-cavity seen from the outside, showing kidney, etc. (slightly diagrammatic); $\times 28$.

B. Half of a transverse row of teeth from the radula; $\times 1400$.

great, and it is probable that the two species are fairly closely related, notwithstanding the dissimilarity in the apical sculpture of their shells.

Trachycystis pura Conn., 1922.

(Plate IV, fig. 15.)

1922. *Trachycystis pura* Conn., A.M.N.H. x, p. 118. D.

Hab. L. MARQUES. Mount Vengo, 5500 ft. (type, Cressy).

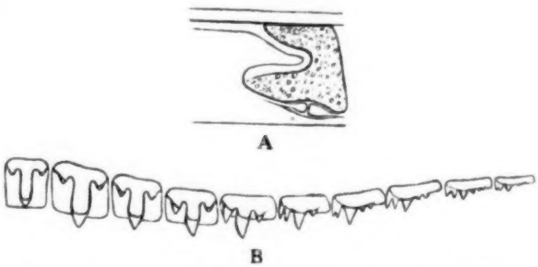
CAPE PROVINCE. Thomas River, Cathcart (Miss Davidson).

Easily distinguishable from its minute confrères by its milky shell and comparatively strong, close, radial striae.

The kidney (text-fig. 13, A) extends from the pericardium upwards to the rectum, and has two anterior prolongations: a lower one, which is about ¼ mm. long, occupying the usual position between the heart and pulmonary vein, and the primary ureter, which arises from its front end; and an upper prolongation, which is nearly as large as the lower one, and is situated between the rectum and the posterior end of the secondary ureter. The kidney contains numerous spherical or oval concretions, which are largest in the upper anterior prolongation, where some of them attain a diameter of ·02 mm.

The jaw is about ·105 mm. long, slightly curved, and very thin, but shows traces of vertical folds.

The radula of the specimen examined (text-fig. 13 B) measures ·32×·105 mm. when flattened out, but the snail may not have been quite full-grown. The central and lateral teeth are tricuspid, with quadrate basal plates. Their mesocones are large, those of the lateral teeth extending a little beyond the posterior edges of the basal plates. Their ectocones and endocones are short, but the endocones of the lateral teeth are slightly larger than the ectocones—an unusual feature. The first lateral teeth on each side are disproportionately large, being much bigger than the central teeth; probably this is connected with the fact that the number of lateral teeth is unusually small. In the marginal teeth the basal plates are much shorter, especially in the outer teeth, which are remarkably short in pro-



TEXT-FIG. 13.—*Trachycystis pura* Conn., Vengo Mountain.

A. Kidney, heart, etc., seen from the outside (slightly diagrammatic); ×36.
B. Half of a transverse row of teeth from the radula; ×1400.

portion to their breadth. The endocones of the marginal teeth have longer cutting points, but they are often split into two cusps. The ectocones of the marginal teeth also become divided into two, or sometimes three, small cusps, but they are very much shorter than the endocones and mesocones. The transverse rows of teeth are not straight, but slope backwards from the centre in the region of the lateral teeth, and forwards again in the region of the marginal teeth. The radular formula is: $(6+3+1+3+6)\times 66$.

It will be seen that in this species the radula, as well as the shell and kidney, is of a slightly specialised type, although it agrees with the other members of the Endodontinae in all its more important characters. The backward trend of the lateral teeth, and the large size of the first one on each side, make this radula easy to distinguish from any of the others illustrated in this paper. In some respects it resembles the radula of the American species *Helicodiscus lineatus* (Say),* although that species has a much smaller and narrower central tooth.

* See Watson: Proc. Malac. Soc., vol. xiv, 1920, p. 12, fig. 4e.

Trachycystis vengoensis Conn., 1922.

(Plate IV, fig. 16.)

1922. *Trachycystis vengoensis* Conn., A.M.N.H. x, p. 118. D.

Hab. L. MARQUES. Mount Vengo, 5500 ft. (Cressy).

The jaw measures about $\cdot 1 \times \cdot 02$ mm. It is curved, very thin, and has little or no visible sculpture.

The radula (text-fig. 14) measures $\cdot 29 \times \cdot 11$ mm. when flattened out. The central and lateral teeth are tricuspid, with quadrate basal plates. Their mesocones are rather long, reaching the posterior edges of the basal plates, the cutting points being short in the inner teeth but longer in the transitional teeth. Their ectocones are rather small; their endocones are also small and a little narrower than the ectocones in the inner lateral teeth, but become longer in the transitional teeth, with larger cutting

TEXT-FIG. 14.—*Trachycystis vengoensis* Conn., Vengo Mountain. Half of a transverse row of teeth from the radula; $\times 1600$.

points. The marginal teeth have much shorter bases; their mesocones have rather long points; their ectocones are divided into two or three minute pointed cusps, and their endocones, which are slightly longer than the ectocones, also tend to split into two. In the radula figured the third marginal tooth on the right side is abnormally without an endocone. The transverse rows of teeth are almost straight in the middle, but bend slightly forwards on each side in the region of the marginal teeth. The radular formulae of the two specimens examined are: $(6+6+1+6+6) \times 72$, and $(6+6+1+6+6) \times 80$. The radula is thus of the normal type found in the Endodontinae, although the teeth are very small.

The nearest relations to this microscopic species have been described under the names of *Pyramidula* (*Gonyodiscus*) *ugandana* Smith,* and *Gonyodiscus smithi* Dautzenberg and Germain,† the shells of both of which so closely resemble that of *vengoensis* that they must surely be congeneric. It differs from the type of *ugandana*, which is a larger shell, in having an infinitesimally sharper and narrower suture, finer sculpture, a narrower

* Journ. of Conch. x (1903), p. 317.

† Rev. Zool. Africaine iv (1914), p. 19.

and deeper umbilicus, and slightly more rapidly increasing whorls ; while it appears to be higher in the spire, with weaker sculpture and considerably less rapidly increasing whorls than *smithi.*

Trachycystis pinguis (Krs.), 1848.

1848. *Helix pinguis* Krs., Südafr. Moll., p. 75, pl. 4, fig. 19. D.F.
1879. *Hyalina pinguis* Krs., Mts., Monatsb. Ak. Wiss. Berlin, p. 736. L.
Hab. L. Marques. Tette (Peters).

It is most improbable that the shells cited by von Martens can be the true *pinguis* of Krauss. Dr. Thiele kindly informs me that the set in the Berlin Museum, which probably represents them, consists of rather immature examples, of which the largest measures $4{\cdot}7 \times 2{\cdot}9$ mm. They are in any case congeneric with *Gudeëlla mixta* Smith, which seems, however, to be proportionately rather greater in diameter and less in altitude.

Subfamily PUNCTINAE.

Genus Punctum Morse, 1864.

Punctum hottentotum (M. and P.), 1891.

1891. *Helix hottentota* M. and P., A.M.N.H. viii, p. 239. D.
1892. ,, ,, ,, ,, ix, p. 94, pl. 4, fig. 6. F.
Hab. L. Marques. Bandula Siding (Mcdowell).

The shells from this locality agree fully with those of the same species from Jesmond and many other southern districts. It is interesting to set on record that I have recently been shown by Mr. J. Hewitt, Director of the Albany Museum, a living example of *P. hottentotum* which was found among the feathers of a loerie, *Turacus corythaix*, shot by Dr. G. Rattray at Hogsback, Amatola Mts., C.P. From its position, the snail appeared to have adhered there during the bird's lifetime, a fact which may afford some explanation of its comparatively wide distribution.

Some notes on the anatomy of this species are given below.*

The foot has well-marked peripodial grooves. The tentacles are dark, and the top of the head is also more or less pigmented. The posterior aorta and its principal branches, and to some extent the efferent pulmonary vein, are coated with a conspicuous white deposit ; and this is also true of the afferent pulmonary vein that runs down the hinder margin of the mantle-edge. The posterior part of the roof of the mantle-cavity shows some streaks of dark pigment.

* These notes are taken from specimens found at Belle Vue, Upper Mooi River, Natal, for which the writer is indebted to Mr. H. C. Burnup of Pietermaritzburg.

The jaw seems to be composed of a number of fibrous plates, as in other species of the Punctinae.

The radula (text-fig. 15) is long in proportion to its breadth, measuring $\cdot 625 \times \cdot 125$ mm. when flattened out. The central teeth are tricuspid, but rather narrow, with oblong basal plates. Their mesocones are less than half the length of the basal plates, and their ectocones are extremely small. The lateral teeth are not so narrow as the central teeth. Their mesocones are about half the length of the basal plates, while their ectocones scarcely exceed half the size of the mesocones. In addition to these two principal cusps, each lateral tooth has an exceedingly minute endocone on the inner side of the mesocone, and two other minute cusps, one between the mesocone and the ectocone and one external to the ectocone. The basal plates of the inner lateral teeth are rather long, and taper somewhat posteriorly, their inner edges being oblique, while their outer edges are roughly parallel to the

TEXT-FIG. 15.—*Punctum hottentotum* (M. and P.), Belle Vue, Upper Mooi River, Natal. Half of a transverse row of teeth from the radula; $\times 1400$.

length of the radula. In the outer teeth the basal plates tend to become shorter, and they are broader posteriorly, as their outer as well as their inner edges are oblique. In the central and inner lateral teeth the basal plates are hollowed towards their posterior edges, which are consequently exceedingly thin in the middle. Towards the outer margins of the radula the teeth not only become gradually smaller, but they also become shorter, and their cusps become relatively longer and narrower, the minute endocones being rather more developed. In fact, the last two or three teeth on each side resemble the transitional teeth of such forms as *Endodonta* (*Afrodonta*) *novemlamellaris*; but true marginal teeth can scarcely be said to occur in the present species. The transverse rows of teeth trend slightly forwards on each side. The radular formula is: $(15+1+15) \times 105$.

The radula of another specimen is a little smaller, measuring $\cdot 525 \times \cdot 115$ mm. Its formula is: $(14+1+14) \times 94$.

Although this species has hitherto been usually placed in the genus *Trachycystis*, its radula shows that it belongs to the Punctinae. It differs from *Punctum pygmaeum* (Drap.) and *P. pallidum* Conn., in that the mesocones of the lateral teeth are considerably larger than the ectocones; but in this respect it agrees with some of the other members of the group, such

as *Punctum cryophilum* (Mts.), from Abyssinia, of which the radula has been figured by Jickeli.* It is true that Jickeli does not show the three smaller cusps, but these cusps are so minute in *Punctum* and *Laoma* that they can only be clearly seen under a $\frac{1}{12}$-in. oil-immersion objective, and have therefore generally been overlooked until recently.

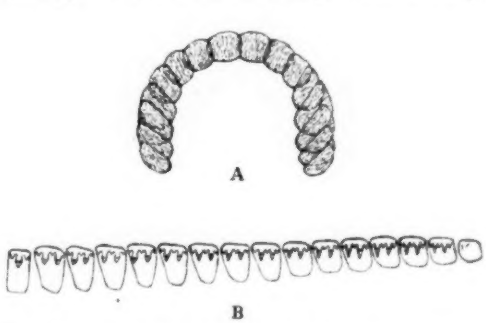
Punctum pallidum Conn., 1922.

(Plate IV, fig. 17.)

1922. *Punctum pallidum* Conn., A.M.N.H. x, p. 119. D.

Hab. L. Marques. Mount Vengo, 5500 ft. (Cressy).

The jaw (text-fig. 16, A) is horse-shoe shaped, and is composed of about



Text-fig. 16.—*Punctum pallidum* Conn., Vengo Mountain.

A. Jaw; ×300.

B. Half of a transverse row of teeth from the radula; ×1600.

eighteen thin imbricating plates, which appear to have a fibrous structure. The plates are largest laterally, where they overlap one another to the extent of about half their width; in the middle of the jaw they only overlap very slightly.

The radula (text-fig. 16, B) measures ·32×·08 mm. when flattened out. The individual teeth are extremely small, with minute cusps. The central teeth are rather narrow, with oblong basal plates. They are tricuspid, but the mesocones are only about one-third the length of the basal plates, and the ectocones about one-third the length of the mesocones. The lateral teeth, which are slightly broader than the central teeth, each have two principal cusps, the mesocone and the ectocone, which are similar to each other and of about the same size as the mesocones of the central teeth. Alternating with these two cusps there are three more, exceedingly minute

* Nova Acta Acad. Cæs. Leop.-Carol., vol. xxxvii, 1874, p. 55, pl. i, fig. 4.

cusps, of which the inner one represents the endocone. The basal plates of the lateral teeth are oblique, although in the inner teeth they taper posteriorly in the same way as in *hottentotum*. Towards the edges of the radula the basal plates become somewhat shorter, and the cusps become a little longer and narrower, but there are no true marginal teeth. The transverse rows of teeth trend forwards a little on each side, forming a slight angle in the centre. The radular formula is $(15+1+15)\times 85$.

The teeth of this little snail closely resemble those of the European species *P. pygmaeum* (Drap.).* The discovery of undoubted members of the Punctinae in this region is of special interest, for although this subfamily is widely distributed, like many groups of minute snails, and has long been known to occur in Abyssinia, as well as in Europe, Asia, North America, Australia, and New Zealand, and has also been found in Juan Fernandez, off the west coast of South America,† it does not seem to have been hitherto definitely recorded from South Africa, notwithstanding that the South African molluscan fauna has many features in common with that of the Australian Region, where this group is well developed.

Family ENIDAE.

Genus Conulinus von Martens, 1895.

(=*Edouardia* Gude, 1914.)

It is now accepted that von Martens' designation of *B. velutinus* Pfr. as type of *Pachnodus* Albers is valid and that Bourguignat was in error in his subsequent substitution of *B. spadiceus* Mke. as genotype. As these two species differ considerably in both conchological and anatomical features, it becomes necessary to find a new generic name for the group to which the last mentioned belongs.

There is a very closely graded chain of links uniting the large carinate species, such as *spadiceus* Mke. and *natalensis* Krs., with the less carinate *conulus* Rve. and *maritzburgensis* M. and P., while from these there is easy transition to the smaller northern forms, *metuloides* Smith, *metula* Mts., etc. Anatomical research tends to prove that all the South African species are congeneric, and that consequently any genus-name already applied to one of them will be applicable to all.

The oldest of such appears to be *Conulinus*, which von Martens founded in 1895 as a subgenus of *Buliminus* for three new species, *ugandae*, *hildebrandti*, and *metula*. He fixed no type, but mentioned that *ugandae* was "verwandt mit *B. conulus* Rv." In 1897 he again dealt with *Conulinus*,

* See Bowell: Proc. Malac. Soc., vol. xi, 1914, p. 159.

† Odhner: Nat. Hist. Juan Fernandez and Easter I., vol. iii, 1922, p. 227.

this time nominating *conulus* "Pfr." (a slip of the pen for Rve.) as genotype.

In 1914 Gude * rejected *Conulinus* Mts. on account of the earlier *Conulina* Bronn, 1835, substituting the name *Edouardia*, with *conulus* "Pfr." (another slip of the pen for Rve.) as type.

As doubt existed both as to whether *Conulinus* Mts. was valid and whether *conulus* was available as genotype, the matter has been submitted to the International Commission on Zoological Nomenclature, whose decision is that "*Conulinus* von Martens, stands, with genotype *Bulimus conulus* Reeve." *Edouardia* Gude must thus be placed in synonymy.

Conulinus conulus (Rve.), 1849.

1849. *Bulimus conulus* Rve., Conch. Icon. pl. 78, fig. 577. D.F.

Hab. L. MARQUES. Rikatla (Junod).

I have been unable to verify the truth of this record; Reeve's rare species has often been misidentified, and this may be a case in point.

Conulinus meridionalis (Pfeiffer), 1847.

1847. *Bulimus meridionalis* Pfr., P.Z.S., p. 231. D.

1848. ,, ,, ,, Rve., Conch. Icon., pl. 56, fig. 370. D.F.

Hab. L. MARQUES. Matolla (Penther); Tembe; Magude; Morakwen; gardens in Lorenzo Marques (Junod).

Conulinus natalensis (Krs.), 1846.

1848. *Bulimus natalensis* Krs., Südafr. Moll., p. 78, pl. 5, fig. 1. D.F.

Hab. L. MARQUES. Rikatla (Junod); Delagoa Bay (smaller variety in Vienna Museum, fide Sturany).

I have been unable to verify either of these records, but do not doubt that that of Sturany refers more nearly to *meridionalis* than to *natalensis*.

Conulinus tumidus (Gibbons), 1877.

(Plate IV, fig. 20.)

1877. *Buliminus tumidus* Gibbons, Taylor, Q.J. of C., i, p. 254, pl. 2, fig. 4. D.F.

Hab. L. MARQUES. Mtisherra R. Valley (Cressy).

A coastal species described from Zanzibar and known as far north as the Shimbi Hills, Kenya Colony (Kemp). Owing to confusion in the Gibbons collection, as represented in the British Museum, wherein 3 different species were labelled as types of *C. tumidus*, I have referred the matter to Mr. J. W.

* Fauna of Brit. India, Moll., ii, p. 260.

Taylor, who kindly informed me that, to the best of his recollection, the individual which I now figure was that on which his description was based. There is some discrepancy between the photograph and the original engraving, but the dimensions of the former agree exactly with those given in the description, and there can be no doubt but that my figure correctly represents the actual type.

The single example found by Cressy is very slightly more obese, and therefore with slightly less acute spire, than the type, and its umbilicus is nearly twice as narrow, but it is hardly varietally separable.

Conulinus metuloides (Smith), 1899.

1899. *Buliminus* (*Conulinus*) *metuloides* Smith, P.Z.S., p. 587, pl. 33, fig. 43. D.F.

Hab. L. Marques. Mtisherra R. Valley (Cressy).

Conulinus sordidulus (Mts.), 1897.

(Plate IV, fig. 19.)

1897. *Buliminus sordidulus*, Mts., D.-O.-A. iv, p. 65, pl. 3, fig. 30. D.F.

Hab. L. Marques. Wanetsi R., Magude District (Bell Marley).

This Kenyan species is only known to me from the above reference and it is with considerable diffidence that I assign to it the shells from the Wanetsi River. They are about $\frac{3}{4}$ mm. narrower in proportion than von Martens' dimensions, and appear to be more faintly angled at the periphery than the specimen he figures; his illustration, however, may not be quite accurate, since he describes the last whorl as rounded, and the shells agree so closely in all other respects with his description and figure that I do not like to separate them without further knowledge of the species.*

Conulinus transvaalensis (M. and P.), 1893.

1893. *Buliminus transvaalensis* M. and P., A.M.N.H. xii, p. 105, pl. 3, fig. 6. D.F.

Hab. L. Marques. Makulane, under bark (Junod).

Conulinus junodi (Conn.), 1922.

(Plate IV, fig. 18; Plate VIII, figs. 5–7.)

1922. *Edouardia junodi* Conn., A.M.N.H. x, p. 120. D.

Hab. L. Marques. Lebombo Mountains (Junod).

The largest shell in the series was selected as the type; it contains 5

* While revising proofs, I have been able to examine an authentic example of *sordidulus*; it is identical with the Magude shells.

whorls and measures: alt. 10·8, lat. 10·2 mm. A smaller shell, containing nearly 5 whorls, measures 8·6×8·6 mm.

External features of animal.—The foot-sole is bluntly pointed at the hind end, and is inconspicuously divided longitudinally into a median pale area, and lateral more or less pigmented areas, crossed by transverse grooves. Shallow peripodial grooves are present, but as these run along the very edge of the foot there is no distinct foot-fringe. A caudal mucous pore is absent. The top of the hinder end of the foot is bluntly angled or keeled, but the keel is not developed into a serrate crest, as it is stated to be in some species.* A network of irregular grooves divides the skin into numerous small rugae, but larger and more regular grooves are scarcely developed. There is a broad and ill-defined dark band on each side of the head and neck.

Mantle and pallial organs.—The mantle-edge bears a right body-lobe beneath the respiratory orifice, and two widely separated left body-lobes. There are no shell-lobes. The thin skin covering the mantle-cavity and visceral hump is translucent and unpigmented; but the dark liver of the upper whorls is largely covered by a white network formed by the branches of the posterior aorta (Pl. VIII, fig. 7).

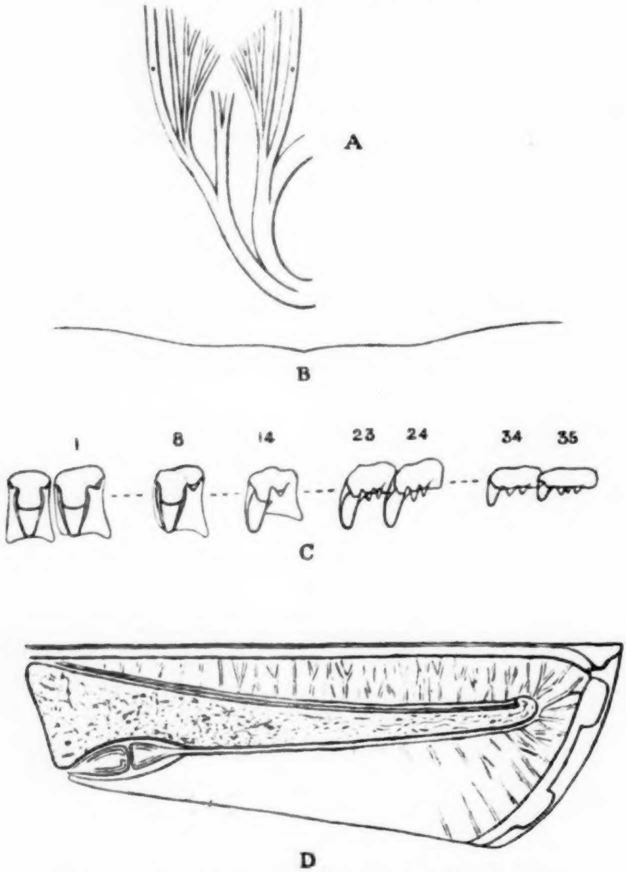
The kidney is long, and gradually merges in front into the ureter, which passes forward to within a short distance of the mantle-edge, and then abruptly bends round and opens (text-fig. 17, D). From this point a fold passes backwards close to the upper edge of the ureter and kidney, overhanging a groove which forms an incipient recurrent ureter. This channel, however, is open throughout its length.

The main pulmonary vein, which runs beneath the ventral edge of the ureter and kidney, receives several short branches at its anterior end; and other small veins cross the roof of the mantle-cavity below the rectum and near the mantle edge, as shown in the figure.

Central nervous system (Pl. VIII, fig. 6).—The nerve-ring is small and surrounds the oesophagus, salivary ducts, and buccal retractor, being too small to allow the buccal mass to be retracted through it. The large cerebral ganglia are united by a fairly short, but rather narrow, arched cerebral commissure. The buccal commissure is also rather short. The pedal ganglia lie, as usual, close together, and each is obscurely divided by a slight dorsal furrow into a large anterior and a smaller posterior portion. The anterior portions are united by the broad anterior pedal commissure, and bear on their upper sides the otocysts. The posterior portions are united by the narrower posterior commissure. The cerebro-pleural connectives are relatively short, and the visceral ganglia are closely aggregated and somewhat compressed laterally, although they are all quite

* See Pilsbry: Bull. Amer. Mus. Nat. Hist., vol. xl, 1919, p. 306.

distinct from one another, as may be seen from the figure. The right parietal ganglion is, as usual, much larger than the left.



TEXT-FIG. 17.—*Conulinus junodi* (Conn.), Lebombo Mountains.

A. Principal retractor muscles.
B. Course of a transverse row of teeth in the radula.
C. Representative teeth from the radula ; $\times 500$.
D. Roof of mantle-cavity seen from within, showing kidney, etc. (slightly diagrammatic) ; $\times 8$.

Digestive system.—The jaw is regularly arched, and measures about 1·1 mm. in length. It is smooth except for a few slight traces of vertical folds.

The radula (text-fig. 17, C) measures about $2{\cdot}75 \times 1$ mm. when flattened out (the shells of the same specimens measuring about $10 \times 9{\cdot}5$ mm.). The central teeth are tricuspid, and slightly narrower than the lateral teeth, which are bicuspid. The mesocones of the central and lateral teeth are large, with lateral flanges; their points are very blunt, being almost truncated and often minutely notched. The ectocones are small, especially in the central teeth, where they are almost vestigial. The basal plates are quadrate, with thickened outer posterior angles. The marginal teeth have much shorter basal plates, and are nearly all tricuspid, each having a long blunt slightly curved mesocone and two small pointed ectocones. In a few of the marginal teeth, however, there are three ectocones instead of two. The inner marginals are slightly oblique, but this is not the case with the outer teeth, which have shorter cusps and broad short bases. The transverse rows of teeth are not quite straight, but curve forwards a little on each side in the manner shown in text-fig. 17 B. The radular formula of the specimen figured is $(21+14+1+14+23) \times 145$; that of another example is $(21+14+1+14+21) \times 140$.

The oesophagus, though capable of distension, is normally narrow and folded longitudinally within. The salivary glands almost surround it in the middle. It leads into a large elongated stomach, the hinder end of which is seen in the centre of fig. 7 (Pl. VIII). The intestine, rectum, and liver are of the usual type.

Free retractor muscles (text-fig. 17, A).—The columellar muscle is divided almost from its origin into two main strands. The right divides further forwards into the buccal retractor, which is forked in front, and the left cephalic retractor, which gives branches to the front end of the foot as well as to the upper and lower tentacles on the same side. The right main retractor divides into the broad muscle to the hinder end of the foot and the right cephalic retractor, which branches similarly to the left one, the retractor of the right upper tentacle passing between the penis and vagina.

Reproductive system.—Owing to the immaturity of the specimens the genital organs were in a very rudimentary condition; but the male organs, although extremely small, were sufficiently developed to show that they were of the same type as those of the other South African members of the genus (Pl. VIII, fig. 5). The penis is rather narrow, and bears laterally a long appendix. Posteriorly, where it unites with the rather thick epiphallus, it bears a short and broad, curved caecum, from the side of which there springs a slender flagellum. The penial retractor is forked, one branch being inserted at the junction of the epiphallus and penis, and the other being attached to the penial appendix towards its proximal end.

This species is founded on four examples, none of which are quite mature, and it is obviously nearly related to *C. mcbeanianus* (Bnp.) which it resembles in habit, being an underground, rather than arboreal species. I have only been induced to accord it specific rank after consideration of the evidence adduced by the anatomy, but there are also certain marked points of difference between the shells. *C. mcbeanianus* differs from the present species in that the whorls are considerably less tumid and less rounded at the periphery, there being in young shells of *junodi* hardly a vestige of carination, which is very marked in immature *mcbeanianus*, while in the latter the umbilicus is a little narrower and considerably less open than in the new species; the roof of the mantle-cavity is ornamented with dark and opaque white patches; the recurrent ureter forms a closed duct towards its anterior end, instead of being an open groove throughout its length; the jaw is more strongly folded, and there also seem to be some slight differences in the radula. There can be no doubt therefore that *junodi* is specifically distinct.

Its general anatomy is of the same type as that of the other South African species of *Conulinus* which have been dissected. Hitherto the larger and broader species of this genus have usually been erroneously placed in *Pachnodus*, but in their anatomy these species closely resemble the smaller South African forms, whereas the type of the genus *Pachnodus*—*P. velutinus* (Pfeiffer) from the Seychelles—differs from them considerably in its reproductive organs and still more in its radula.* This group of snails from South and East Africa is also quite distinct anatomically from the Palaearctic genus *Ena* (or *Buliminus*), in which many writers have placed it.

Genus Rhachis Albers, 1850 (*emend*).

(=*Rachisellus* Bourguignat, 1889.)

The necessity for dividing *Rhachis* into three distinct genera† on anatomical grounds raises the determination of its genotype to so high a pitch of importance that it may be well to recount, once again, the whole of the facts concerning it, in hope of settling the question once for all.

In the first edition of Die Heliceen, 1850, Albers proposed the subgenus *Rachis*, with *pallens* Jonas as the first species, and included therein *férussaci* Dkr., but did not nominate a genotype.

In 1855 ‡ Pfeiffer emended Albers' spelling to *Rhachis*, which appears

* See Schacko, in Möbius: Beitr. z. Meeresfauna v. Mauritius u. d. Seychellen, 1880, pp. 337–341, pl. xix, figs. 13–23; and Wiegmann: Mitt. Zool. Samml. Mus. Nat. Berlin, vol. i, 1898, pp. 81–85, pl. iv, fig. 8.

† See Thiele, Arch. f. Moll.-k. liii, 1921, pp. 149, 150.

‡ Mal. Blätt. ii, p. 161.

to me to be correct, and further included in the subgenus *B. punctatus* Anton, again without nominating a genotype.

In the second edition of Die Heliceen, 1860, von Martens adopted Pfeiffer's emended spelling of the subgeneric name and designated *punctatus* as type.

In 1889 Bourguignat repudiated von Martens' designation, on the ground that *punctatus* was not included in Albers' original list, and nominated *pallens* as type of *Rachis*, while creating a new genus, *Rachisellus*, with *punctatus* as genotype.

Now, Bourguignat's procedure would have been perfectly correct, were it not possible to prove beyond all doubt that *férussaci* Dkr. is a synonym of *punctatus*, so that, as *férussaci* was included in Albers' original list, *punctatus* is available as type of Albers' genus.

Dunker first published a brief description of *B. férussaci* in 1845, giving the length of the shell as 7 lines, and stating that only 3 specimens, all agreeing well with each other, were collected. Their locality was Loanda.

In 1853 * he repeated the description, adding that the species had also been recently collected on the east coast of Africa, and published a figure of the shell. The length of this is about 9, rather than 7 lines, but the other figures on the plate are natural size, and it appears probable that the numeral 7 in the description is a misprint, such as might easily be made for the numeral 9. The shell figured is remarkable for being considerably above the average size of *punctatus* and for having a few transverse flammules on the last whorl, which are seldom so prominent in that species.

There appears to be no doubt that this original set of *férussaci* were acquired by Hugh Cuming, who was in frequent correspondence with Dunker. The Cuming collection in the British Museum contains a set of 3 shells, labelled "férussaci, Dkr. Loander." They agree well together, being of the same outstanding dimensions as Dunker's figure, which in itself is strong evidence in favour of their being his originals, but one of them (Pl. IV, fig. 22) not only coincides with it in outline, but shows vertical flammules similar to those of the figure on the last whorl. In the front view of the figure, these are spaced a little closer together to the left than in the actual shell, while the back view shows 3 flammules and the shell one more, but the rest of the colour pattern agrees so closely that it is practically impossible not to accept the figure as a fair, but very slightly inaccurate reproduction of the Cumingian shell.

These specimens of *férussaci* are completely identical with Indian examples of *punctatus*, so that the former must be placed in synonymy and *B. punctatus* stands as genotype of *Rhachis*.

* For references see p. 160.

Rhachis punctata (Anton), 1839.

(Plate IV, fig. 22.)

1839 *Bulimus punctatus* Ant., Verz. Conch. Samml., p. 42. D.

1845 ,, *férussaci* Dkr., Zeitschr. f. Malak., ii, p. 164. D.

1853 ,, ,, ,, Novit. Conch., Suppl. ii, p. 6, pl. 1, figs. 35–36. D.F.

1854, 55 *Bulimus punctatus* Ant., Pfr., Conch. Cab., p. 229, pl. 62, figs. 22–24. D.F.

Hab. MOZAMBIQUE (Gibbons; Frey); Querimba I. (Peters).

L. MARQUES. Tette (Peters).

The locality Lebombo Mts. (Barber) given in my reference list probably relates to the next species. As mentioned overleaf, I illustrate the putative type of *férussaci*, Dkr., which is an excellent example of mature *punctata*.

Rhachis jejuna (M. and P.), 1893.

(Plate IV, fig. 21.)

1893. *Buliminus* (*Pachnodus*) *jejunus* M. and P., A.M.N.H. xii, p. 106, pl. 3, fig. 7. D.F.

Hab. L. MARQUES. Lebombo Mts., under bark of dead tree (Junod); Wanetsi R., Magude District (Bell Marley).

This species, described from the Northern Transvaal, was based on very immature examples, whose close resemblance to similar specimens of *punctata* caused me to unite the two species in my Reference List. Now that adult shells are to hand it may be advisable to regard them as distinct. The spire of *jejuna* has slightly convex sides, the aperture is comparatively longer, thus appearing narrower, and the microscopic spiral sculpture is, on the average, stronger than in *punctata*, though the last-mentioned feature is very variable in the latter species.

Rhachis petersi (Pfeiffer), 1855.

1855. *Bulimus petersi* Pfr., P.Z.S., p. 97. D.

Hab. L. MARQUES. Tette (Peters).

Text-fig. 17, E is a photograph of the type of this hitherto unfigured species.

TEXT-FIG. 17, E.—*Rhachis petersi* (Pfr.), type, ×1.

Rhachis catenata (von Martens), 1860.

1860. *Bulimus (Rhachis) catenatus* Mts., Mal. Blätt. vi, p. 212, pl. 2, fig. 7. D.F.

Hab. MOZAMBIQUE. Querimba I. (Peters).

Text-fig. 17, F represents a paratype in the British Museum.

TEXT-FIG. 17, F.—*Rhachis catenata* (Mts.), paratype, × 1.

Genus RHACHIDINA Thiele, 1911.

Shell usually perforate, comparatively globose, of moderate size and frail texture, with a tendency to expansion of the peristome when fully developed. The radula has been figured by Thiele.*

Rhachidina melanacme (Pfr.), 1855.

1855. *Bulimus melanacme* Pfr., P.Z.S., p. 96, pl. 31, fig. 8. D.F.

1889. *Pachnodus sesamorum* Ancey, Bgt., Moll. Afr. équat., p. 66, pl. 3, figs. 2–3. D.F.

Hab. MOZAMBIQUE, ex sacks of sesame (*sesamorum*, Ancey). Querimba I. (Peters).

L. MARQUES. Tette (Peters).

The type of this species in the British Museum appears to be a slightly distorted example, the last whorl being unduly swollen in relation to the earlier ones, which are slightly less in diameter than in *R. usagarica* (Smith). The shell also is a little thicker in texture, white, with a very black apex and one thin dark brown peripheral band ; a few small dark brown spots are irregularly grouped on all the whorls. *Sesamorum*, which I have not seen, is certainly a synonym of this or the next species.

Rhachidina usagarica (Smith), 1890.

1890. *Rhachis usagarica* Smith, A.M.N.H. vi, p. 152, pl. 5, fig. 5. D.F.

1897. *Buliminus (Rhachis) melanacme* Pfr., var. *usagaricus* Smith, Mts. D.-O.-A. iv, p. 76. N.

* Arch. f. Moll.-k. liii, 1921, pl. 4, fig. 2.

1898. *Buliminus* (*Rhachis*) *pentheri* Stur., S.A. Moll., p. 65, pl. 2, figs. 47–48. D.F.

Hab. L. MARQUES. Matolla (*pentheri* Penther); Mtisherra R. Valley; Dondo (Cressy).

This gregarious species, described from Usagara, has a wide distribution, having been collected, like *Conulinus tumidus*, as far north as the Shimbi Hills by Kemp.

The shells are very constant in contour, but vary greatly in fasciation. The typical form has 2 bands, one at the periphery and one below it, and the majority of examples from P.E.A. and the Shimbi Hills are of this pattern, but some are unifasciate, lacking the lower band; some are bandless, approximating very nearly to *melanacme* Pfr., while others are trifasciate, with an additional band midway between periphery and suture. All the bands may vary greatly in breadth.*

In 1897 von Martens listed *usagarica* as a variety of *melanacme*, while in 1889 Smith † stated that he considered it specifically distinct. I have not seen the specimens on which the German author based his opinion, and am fully prepared to admit that the two species may prove to be inseparable when more topotypes of *melanacme* are available for examination, but on the material before me it is certainly desirable to maintain distinction between them.

There is no doubt that *pentheri* must be placed in the synonymy of *usagarica*, Dr. Sturany having kindly compared examples of the latter with the type of the former and confirmed my view as to their identity.

Rhachidina dubiosa (Stur.), 1898.

1898. *Buliminus* (*Rhachis*) *dubiosus* Stur., S.A. Moll., p. 64, pl. 2, figs. 45–46. D.F.

Hab. L. MARQUES. Matolla (Penther); Dondo (Cressy).

Very closely allied to *R. braunsi* (Mts.), with which a more extensive knowledge of both species may prove it identical.

Rhachidina mozambicensis (Pfr.), 1846.

1846. *Bulimus mozambicensis* Pfr., Symb. iii, p. 85. D.

1849. ,, ,, ,, Rve., Conch. Icon., pl. 58, fig. 328. D.F.

Hab. MOZAMBIQUE (type in coll. Cuming; Ancey; Gibbons).

L. MARQUES. Rikatla (Junod).

* Since above was in print, I have seen a rare mutation from the Shimbi Hills, which has no upper bands, but four broadish ones between the periphery and umbilicus.

† P.Z.S., p. 586.

Although the last record is plausible, I suspect that it should refer to one of the two foregoing species. Junod mentions that his shells have two longitudinal bands on the base, a feature very unusual in *mozambicensis*, but nearly always present in *dubiosa* and *usagarica*.

Rhachidina spilogramma (Mts.), 1860.

1860. ***Bulimus spilogrammus*** Mts., Mal. Blätt. vi, p. 214, pl. 2, fig. 9. D.F.

Hab. L. MARQUES. Tette (Peters); Mtisherra R. Valley (Cressy).

A beautiful little species, easily recognisable from the author's figure.

Genus RHACHISTIA, nov.*

Type *Buliminus rhodotaenia* von Martens (Conch. Cab. 1901, p. 750, pl. 110, figs. 12–13).

This new genus is rendered necessary for the reception of the group of species, usually with brightly painted, rather large and solid shells, which cannot now be retained in *Rhachis* with *R. punctata*.

The shells are usually broader than those of *Rhachis*, and grow to a far greater size, becoming more solid in maturity than they do in *Rhachidina*; I have not yet found their peristome expanded, as in the last-mentioned genus.

The radula is of a specialised arboreal type, as will be seen from the figures of Sarasin † and Thiele.‡ It differs considerably from that found in any of the preceding genera, although in some respects the anatomy of *Rhachistia* seems to be very similar to that of *Conulinus*.

Judging from their radula, *abortiva* and *bewsheri* Morel., *erlangeri* Kob., *burnayi* Dhrn., *histrio* Pfr., *moluensis* Kob,. *sanguinolenta* Barcl., *sticta* Mts., and *zonulata* Pfr. belong to this genus, while from the shells alone it probably includes, inter alia, *gomezi*, Sow., *venustus* Morel., *neuricus* Rve., *picturatus* Morel., *ganalensis* Kob., *trichrous* Mts., *pallens* Jonas and *aldabrae* Mts.

Rhachistia rhodotaenia (Mts.), 1869.

var. *andradensis* Germain, 1918.

1918. *Rachis* (*Rachis*) *rhodotaenia* Mts., var. *andradensis* Germ., Bull. Mus. Paris, xxiv, p. 155. D.

Hab. L. MARQUES. Andrada (Vasse).

* *ῥαχιστος*, cut or cleft out of.

† Land-Moll. Celebes, 1899, pl. 31, fig. 305.

‡ Arch. f. Moll.-k. liii, 1921, pl. 4, fig. 1.

Rhachistia sticta (Mts.), 1860.

1860. *Bulimus* (*Rhachis*) *stictus* Mts., Mal. Blätt. vi, p. 211, pl. 2, fig. 6. D.F.

Hab. L. MARQUES. Tette (Peters); Manica Land (Selous); Gorongozo District (Wells Cole); Mtisherra R. Valley; Dondo District; Zangwe Basin (Cressy).

This species attains much greater dimensions than have hitherto been attributed to it, the largest specimen known to me measuring 26·3 × 13·0 mm. The beautiful pink and yellow markings soon fade away in weathered shells, but the black spots usually remain as a fairly safe guide to correct identification.

FAMILY PUPILLIDAE.

The arrangement of the genera here adopted is in accordance with recent volumes of Pilsbry's Manual.

SUBFAMILY PUPILLINAE.

Genus PUPOIDES Pfr., 1854.

(=*Leucochiloides* Pfr., 1881.)

Pupoides coenopictus (Hutton), 1834.

1834. *Pupa coenopicta* Hutt., J.A.S. Bengal, iii, pp. 85, 93. D.
1912. *Leucochiloides soror* Preston, P.Z.S., p. 188, pl. 31, fig. 17. D.F.
Hab. MOZAMBIQUE (Layard).
L. MARQUES. Wanetsi R., Magude District (Bell Marley).

The specimens from both the above localities agree perfectly with *soror*, Preston, which, however, Pilsbry considers synonymous with the Indian *coenopictus*; they certainly do not appear even subspecifically distinct.

SUBFAMILY VERTIGININAE.

Genus NESOPUPA Pilsbry, 1900.

Subgenus AFRIPUPA Pilsb. and Cooke, 1920.

Nesopupa (*Afripupa*) *corrugata* (Preston), 1912.

Hab. L. MARQUES. Bandula Siding (Mcdowell).

The local race is slightly shorter than that from the Victoria Falls, the only other known habitat of this species; the shells are perfectly conspecific, however, and remarkable for the peculiar corrugated surface from which they derive their name.

Nesopupa (Afripupa) vengoensis sp. n.

(Plate IV, fig. 23.)

The minute shell is almost an exact replica of *N. griqualandica* (M. and P.),* but is slightly less strongly striate, and differs clearly and constantly in dentition, the lower palatal fold being absent and the basal tooth so much more deepset that in some specimens it is hardly visible.

Long. 1·6, lat. 0·8 ; apert. alt. 0·5, lat. 0·5 ; last whorl 1·0 mm.

Hab. L. Marques. Mount Vengo, 5500 ft. (Cressy).

I would have been inclined to regard this race as merely a subspecies of *griqualandica*, were it not that the exact number of palatal folds is now considered of sectional importance in the genus *Ptychotrema*, so should presumably be of at least specific importance in the *Pupillidae*.

Nesopupa (Afripupa) bandulana Conn., 1922.

(Plate IV, fig. 24.)

1922. *Nesopupa bandulana* Conn., A.M.N.H. x, p. 119. D.

Hab. L. Marques. Bandula Siding, B. and M. Rly. (Mcdowell).

Nearly allied to *N. bisulcata rhodesiana* Pilsb.,† but easily separable by having a more prominent sinulus, much fainter sculpture, and the extra denticle on the left of the base.

Genus Truncatellina Lowe, 1852.

Truncatellina sykesi (M. and P.), 1893.

1908. *Pupa sykesii* M. and P., A.M.N.H. i, p. 81, pl. 2, fig. 20. N.F.

Hab. L. Marques. Mount Vengo, 5500 ft. (Cressy).

Of the only two examples, one is immature and the other somewhat abnormal, tapering more noticeably than usual. I do not consider, however, that they are separable from the south-eastern form.

Family ACHATINIDAE.

Subfamily ACHATININAE.

Genus Metachatina Pilsbry, 1904.

Metachatina kraussi (Pfr.), 1846.

var. *elongata* (Junod), 1899.

1899. *Livinhacia kraussi*, var. *elongata* Junod, Bull. Soc. Vaudoise, xxxv, p. 279. N.

Hab. L. Marques. Rikatla (Junod) ; Delagoa Bay (juv., Barnard).

* A.M.N.H. xi, 1893, p. 22, pl. 3, fig. 9.

† Man. Conch. xxv, 1920, p. 360, pl. 34, figs. 5–6.

Specimens collected quite recently prove that this elongate race has retained its somewhat specialised form for over 25 years; an average adult shell measures 145×72 mm., as against 98×76 mm. of typical examples from Natal.

Genus ACHATINA Lamarck, 1799.

Achatina panthera (Fér.), 1821.

1821. *Helix (Cochlitoma) panthera* Fer., Tabl. Syst. Moll., pt. 3, p. 53 (or 49).

1846. *Achatina lamarckiana* Pfr., P.Z.S., p. 115. D.

1851. ,, *panthera* Fer., Desh., Hist. Nat. Moll. ii, 2, p. 159, pl. 126, figs. 1–2; pl. 132, figs. 1–2. D.F.

1892–3. *Achatina mossambica* Brancsik, Jahresh. Naturw. Ver. Trenc. Com., p. 116, pl. 6, fig. 2; pl. 10, fig. 2. D.A.R.

1894. *Achatina lechaptoisi* Ancey, Mem. Soc. Zool. Fr. vii, p. 220. D.

Hab. MOZAMBIQUE (Kirk; Gibbons; *mossambica*, Frey; *lechaptoisi*, Layard); Querimba I. (Peters); Quilimane (Stuhlmann).

L. MARQUES. Tette (Peters; Kirk); Inhambane (Gibbons; Bowker); Rikatla (Junod); Andrada (Vasse); Amatongas (Arnold); Chinde (Miss L. Staunton); Headwaters of R. Tristão, Macequece District (Cressy).

Pilsbry (Monograph, xvii, 1904, p. 41, etc.) points out that *A. lechaptoisi* is identical with *mossambica*, and places both in the synonymy of *panthera*. A detailed account of the anatomy of this species by Wiegmann will be found in Mitth. Zool. Samml. Mus. Nat. Hist. Berlin, i, 1898, p. 85, pl. 4, figs. 5–6. Its shell is normally the well-known obese form, usually found along the coast, with blotchy brown and yellow markings and roseate columella, but further inland it is subject to extreme variation in contour, some individuals from Macequece being very much like the coastal race, while others are smaller and more slender, closely resembling the specimen figured by Smith (P.Z.S., 1899, pl. 34, fig. 1). This may be near the var. *minor* mentioned by Junod (Bull. Soc. Vaudoise, xxxv, p. 278) which I have not seen.

Some of the shells from the neighbourhood of Delagoa Bay tend to resemble those of *Achatina immaculata* Lam., for which they have sometimes been mistaken, and from which they scarcely differ except in usually having more distinct dark streaks. Nevertheless the anatomy of a large specimen from the Rikatla district, Delagoa Bay, has been found to agree closely with that of the most slender example from Macequece and the radulae of both these specimens closely resemble Wiegmann's figure. On the other hand, the radulae of two specimens of *A. immaculata* from Zoutpansberg, in the northern Transvaal, differ slightly from those just men-

tioned, the chief points of distinction being that their central teeth are even narrower, and the whole radula is longer, the number of transverse rows being 179 in one specimen and 187 in the other, whereas the radular formula of the Rikatla example is $(88+1+89)\times 143$ and that of the Macequece specimen $(77+1+79)\times 159$. These radular differences between *A. panthera* and *A. immaculata* are not, however, very great, and no marked differences were found in the other organs; it therefore seems not impossible that *immaculata* may eventually prove to be merely a subspecies of *A. panthera* in which the shell and radula have become slightly modified in response to the somewhat different climate and vegetation of the district in which it occurs; both species are remarkable for their roseate columella.

Two examples from Rikatla in the Kimberley Museum show a beautiful variation in colour that is rare in this species. The early whorls are almost colourless, deepening at the 5th into pale buff; in an immature shell, 65×40 mm., possessing 6 whorls and showing marked angulation at the periphery, there are pale rufous flames some distance apart and a few blotches somewhat corresponding to the darker markings of the typical form. In the larger shell, 95×56 mm. with 7 whorls, the streaks have grown nearer together, giving the shell the appearance of having been varnished pale yellow and combed over with a coarse comb.

Achatina immaculata (Lam.), 1821.

1851. *Achatina immaculata* Lam., Desh., Hist. nat. An. s. Vert., II, 2, p. 158, pl. 127, figs. 1–2. D.F.

Hab. L. Marques. Inhambane (Gibbons); Delagoa Bay (fide Pfeiffer).

In view of my note on *A. panthera*, it may be a little doubtful whether these records should not refer to that, rather than to the present species.

The Transvaal form known as *immaculata* is very constant in shape, but variable in colour. The apex is small and acute, and the whorls, about 7½ in number, increase regularly and somewhat rapidly, the last being nearly ¾ of the entire length. Immature shells are sometimes almost white, with rare pale rufous streaks; mature examples all shades from pale buff to dull chestnut, sometimes with darker streaks and blotches; columella, paries, and peristome bright rose-red or pink, often showing round the *outside* of the peristome.

It will be observed that some of these colour-schemes practically merge in that of *A. panthera*, and it is almost impossible, in such cases, to separate the species.

Achatina glutinosa Pfr., 1852.

1852 *Achatina glutinosa* Pfr., P.Z.S., p. 86. D.

1860. ,, *pe ersi* Mts., Mal. Blätt. vi, p. 214. D.

1869. ,, ,, ,, Pfr., Novit. Conch. iii, p. 452, pl. 99, figs. 13–15. D.F.

Hab. L. MARQUES. Tette; Sena (Peters); Andrada (Vasse); Macequece District; Mtisherra R. Valley (Cressy).

Described from Tette by von Martens in 1860 under the name of *A. petersi*, this species has since been proved identical with *glutinosa*, whose original locality, "West Africa," is probably erroneous.

Achatina granulata Pfr., 1852.

1852. *Achatina granulata* Pfr., P.Z.S., p. 66. D.

1899. ,, *schinziana* Mouss., Junod, Bull. Soc. Vaudoise, xxxv, p. 278. L.

L. MARQUES. Cape Delagoa (Plant); Rikatla (Junod).

Dr. Fuhrmann of the Neuchâtel Museum has kindly shown me the actual shells on which the above record of *A. schinziana* was based; they prove to be perfectly normal examples of *granulata*, and it may be accepted that Mousson's species does not occur in Portuguese East Africa.

Achatina nyikaensis Pilsbry, 1909.

1899. *Achatina fragilis* Smith, P.Z.S., p. 591, pl. 35, figs. 3–4. D.F.

1909. ,, *nyikaensis* (=*fragilis* Smith, 1899, non Desh., 1864), Pilsb., Man. Conch. xx, p. 113. N.

Hab. L. MARQUES. Macequece District (Cressy).

Described from Nyasaland; Smith figures two examples, one of which is flammate and the other unicoloured and rather more noticeably sculptured; both varieties are represented in the series from Macequece.

Achatina jacobi da Costa, 1906.

1906. *Achatina jacobi* da Costa, Proc. Mal. Soc. vii, p. 11. D.F.

Hab. L. MARQUES. Macequece District (Cressy).

A very variable species, often misidentified as *craveni* Smith, with which it has little in common.

Achatina natalensis Pfr., 1854.

1854. *Acha'ina natalensis* Pfr., P.Z.S., p. 294. D.

Hab. L. MARQUES. Delagoa Bay (Plant).

The British Museum contains 3 examples of this little known species, of which the type and another are labelled "Cape Natal," and the third as above. It is open to question whether they were really collected in two different localities, but the species does not seem to have been rediscovered since the days of Plant, and its exact habitat cannot therefore be definitely stated. The shells resemble *A. transvaalensis*, Smith, in colour, sculpture, and texture, but are considerably larger and comparatively more obese, measuring respectively 62×30, 64×31, and 65×29½ mm.

Achatina vassei Germain, 1918.

1918. *Achatina* (*Achatina*) *vassei* Germ., Bull. Mus. Paris, xxiv, p. 161. D.F.

Hab. L. MARQUES. Andrada (Vasse); Mt. Vengo (Cressy).

A very distinct member of the small group of narrow shells which includes *A. pfeifferi* Dkr. and *ustulata* Lam. The type is immature, the measurements of a full grown adult being 63·2×24·3 mm.

Achatina vestita Pfr., 1854.

1854. *Achatina vestita* Pfr., Novit. Conch. i, p. 35, pl. 9, figs. 8, 9. D.F.

Hab. L. MARQUES. Near Delagoa Bay (in British Museum).

Achatina fulica (Fér.), 1821.

1849. *Achatina fulica* Fér., Rve., Conch. Icon., pl. 2, fig. 8. D.F.

Hab. MOZAMBIQUE. Frontier S. of Mt. Dedza, Nyasaland (Mrs. Connolly).

Genus LIMICOLARIA Schumaker, 1817.

Limicolaria sculpturata Ancey, 1890.

1890. *Limicolaria sculpturata* Ancey, Bull. Soc. Mal. Fr. vii, p. 346. D.

Hab. MOZAMBIQUE, ex sacks of grain (Ancey).

I have been unable to collect any information about this so-called *Limicolaria*, but the description recalls *Ps. boivini* (Morel.), and I suspect that *sculpturata* may be identical with Ancey's unpublished *Limicolaria borellii*, which I show hereafter, p. 171, to be identical with Morelet's species.

Genus LIMICENA nov.

Shell bulimoid when adult, perforate, columella not truncate, protoconch (2½ whorls) sculptured with 8 or 9 strong microscopic spiral costulae, remainder weakly transversely striate.

Genotype *Limicena nyasana* (Smith), 1899.

1899. *Buliminus (Conulinus) nyasanus* Smith, P.Z.S., p. 586, pl. 33, figs. 41–42. D.F.

Hab. L. Marques. Mtisherra R. Valley (Cressy).

Conchological grounds alone amply justify the creation of a new genus for this remarkable species, which was described from Nyasaland and also occurs in the Palm Kloof, Victoria Falls.

The clear strong spiral sculpture of the protoconch, changing abruptly into transverse striation on the later whorls, is only comparable, among the larger African forms, with that of *Krapfiella* Preston, but *Krapfiella* has a broad apex and an elongate shell, while *Limicena* has a narrow apex and a bulimoid shell, so that I hardly think they belong to the same subfamily, and place the new genus provisionally in the Achatininae. Newly hatched specimens, which crawl about together in large numbers, are easily mistakable at first glance for a small form of *Tropidophora*, and only the present writer's field acquaintance with them has prevented others from describing them as a new species of that genus.

Neuville and Anthony have recorded *nyasana* from Abyssinia.

Subfamily STENOGYRINAE.

Genus Pseudoglessula O. Boettger, 1892.

Subgenus pseudocerastus Germain, 1918.

Pseudoglessula (Pseudocerastus) kirki (Dohrn), 1865.

1865. *Buliminus kirkii* Dhrn., P.Z.S., p. 232. D.

1889. *Bulimus bridouxi* Bgt., Moll. Afr. équat., p. 53, pl. 2, figs. 4–5. D.F.

Hab. Mozambique. Near Cabaceira (type, Kirk).

L. Marques. Amatongas Forest (Arnold); Mtisherra R. Valley (Cressy).

Dr. Germain has pronounced some of the Mtisherra River series to be identical with *bridouxi*; they are also identical with the type specimen of *kirki*, so the synonymy seems firmly established; Bourguignat's species was described from Usagara.

Ps. kirki agrees in sculpture, colour, and texture with *boivini* Morel., but it is a rather more obese form, with a tendency to expansion of the peristome in adult shells, a feature which I have not yet observed in *boivini*.

Pseudoglessula (Pseudocerastus) boivini (Morel.), 1860.

(Plate VI, figs. 1–4.)

1860. *Glandina boivini* Morel., Séries Conch. ii, p. 72, pl. 5, fig. 5. D.F.

1898. *Buliminus movenensis* Stur., S.A. Moll., p. 66, pl. 2, figs. 44–51. D.F.

Hab. L. MARQUES. Delagoa Bay (Connolly); Movene (*movenensis*, Penther); Rikatla; under stones in the Lebombo Mts. (Junod); Andrada

TEXT-FIG. 18.—*Pseudoglessula (Pseudocerastus) boivini* (Morel.). Apical sculpture; ×32.

(Vasse); Maxixe (Lawrence); District N. of Macequece (Cressy); Wanetsi R., Magude District (Bell Marley).

This very widely distributed species varies little in form; the transverse striae of its apex are only very little farther apart than those on the later whorls and it is rather widely umbilicate.

Von Martens (D.-O.-A., p. 62) mentions a *Limicolaria borellii* Ancey, of which I can find no other trace in literature. As represented in the Dautzenberg collection, however, it is identical with the present species.

The following notes on the anatomy of *Ps. boivini* are based on some

slightly immature specimens found under leaves in the bush at Kosi Bay, Zululand, by F. Toppin (Collector for the Natal Museum), and sent to England in spirit by H. C. Burnup, to whom the writer is much indebted.

External features of the animal.—The dermal grooves are similar to those of the next species (Pl. VII, figs. 2, 7), there being, in addition to the usual dorsal and oblique lateral grooves on the neck and the vertical grooves on the front of the head, a conspicuous peripodial groove on each side, the two grooves meeting above a well-marked caudal mucous pore. The hind end of the foot is somewhat truncate in form, and there is no keel.

The dark bands on the sides of the neck seem to be absent, but irregular streaks and spots of dark pigment are scattered over the translucent skin of the mantle and visceral hump, and a larger grey patch occurs just behind the respiratory opening.

The left body-lobe is divided into two widely separated portions, as shown in Pl. VI, fig. 1.

Pallial organs.—The respiratory and excretory organs are shown in the same figure, from which it will be seen that a few small veins occur on the roof of the lung in addition to the main pulmonary vein, which is very prominent. The kidney is long and narrow, with a recurved ureter arising from its front end.

Pedal gland.—This organ is embedded in the muscles of the foot. The glandular tissue completely surrounds the central duct, which is crescentic in transverse section. The gland is simple in structure, and seems to bear some resemblance to that of the Dorcasiinae, as will be seen from Pl. VI, fig. 2.

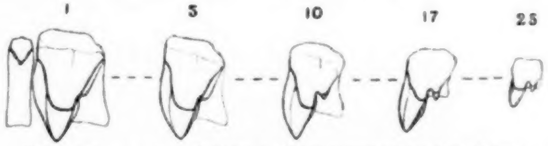
Central nervous system.—The nervous system closely resembles that of the next species (Pl. VII, fig. 3). The nerve-ring may either surround the buccal-mass, or be situated just behind it, as in the specimen shown in Pl. VI, fig. 4. Each cerebral ganglion has a well-marked anterior lobe. The visceral ganglia are rather closely approximated, but not completely united. The buccal ganglia are situated immediately behind the anterior end of the oesophagus, and are oval in form, being joined by a commissure about 0·5 mm. in length.

Digestive system.—The jaw (Pl. VI, fig. 3) is brown, 1·6 mm. long, and transversely striated, the striae being inconspicuous, but a little better developed than in *Ps. cressyi* Conn.

The radula (text-fig. 19) measures 3×1·25 mm., when flattened out. The central teeth are narrow, with single short cusps, but they are not quite so narrow and degenerate as in the next species. The other teeth are also broader and relatively shorter than in *Ps. cressyi*, and the first five on each side are almost unicuspid, the ectocone being reduced to a narrow flange on the outer side of the base of the conical mesocone. They thus

approach the more specialised type found in *Ps. walikalensis* Pilsbry.* In the remaining teeth the ectocones are distinct, though very small in comparison with the large mesocones, which have rather broad inner flanges. No endocones occur, and the marginal teeth are much more asymmetrical than is usual in the Achatinidae. The transverse rows of teeth are almost straight and have not the slight angle in the centre which occurs in the next species. The radular formulae of the two specimens examined were $(25+1+26)\times 76$, and $(25+1+25)\times 73$. The radula-sac projects only a very short distance beyond the muscles of the buccal-mass.

The two salivary glands meet above the oesophagus, which is broad, but does not seem to be dilated sufficiently to form a distinct crop. It continues back into the stomach, whence arises the intestine, which describes



TEXT-FIG. 19.—*Pseudoglessula (Pseudocerastus) boivini* (Morel.), Kosi Bay, Zululand.
Representative teeth from the radula ; $\times 300$.

the usual S-shaped course before finally passing forwards as the rectum (shown on the left of fig. 1, on Pl. VI).

Free retractor muscles.—The arrangement of the principal retractor muscles is shown in Pl. VI, fig. 4, and is similar to that described in the next species. The powerful buccal retractor, which bifurcates in front, is united posteriorly with the left tentacular retractor; while the slender penial retractor and the broad retractor of the foot arise in common with the right tentacular retractor.

Reproductive organs (Pl. VI, fig. 4).—Owing to the fact that the specimens examined were not quite full-grown it is impossible to give a satisfactory description of the reproductive organs of the present species. They appear, however, to resemble those of *Ps. cressyi* in having a rather short free oviduct and receptacular duct, a long vagina, and a penis lined by small papillae and bearing a somewhat swollen terminal appendix, to the posterior end of which the penial retractor and vas deferens are attached, the latter apparently passing forwards to the penis embedded in the outer layers of the wall of the appendix. But the penis and vagina are both much more slender than in the next species, and the receptaculum seminis is also unusually narrow, though it is probable that these features are at least partly due to the immaturity of the specimens.

* Pilsbry: Bull. Amer. Mus. Nat. Hist., vol. xl, 1919, p. 145, fig. 53.

Affinities.—Although originally placed in *Glandina*, this species has usually been assigned to the genus *Buliminus* or *Ena*, and so recently as 1918 Germain made it the type of a new subgenus of *Buliminus* to which he gave the name *Pseudocerastus*.* The present species, however, has certainly no affinities with *Buliminus* or *Ena*, as is evident from the sculpture and form of the shell, the peripodial grooves and caudal mucous pore, the sigmurethrous kidney, the radula with its very narrow central teeth, and the reproductive system in which neither the penis nor the receptacular duct possesses a lateral appendix. Undoubtedly Pilsbry † is right in assigning this species and its allies to the genus *Pseudoglessula*, of which *Pseudocerastus* may be regarded as a subgenus, differing but little from *Pseudoglessula s. s.*, though in some respects more nearly resembling the subgenus *Kempioconcha*.‡

Pseudoglessula is correctly placed in the family Achatinidae; yet it is a decidedly aberrant member of the family, both as regards the radula and the foot with its caudal mucous pore, and so far as we know at present the only other genus to which it seems to be at all closely related is *Krapfiella*.§ It is true that a caudal mucous pore is also found in *Ferussacia* ‖ and *Cryptazeca*, ¶ but while these genera may be more nearly related to the Achatinidae than to the orthurethrous genera with which Pilsbry ** has provisionally associated them,†† it is unlikely that they are at all closely allied to *Pseudoglessula*.

Pseudoglessula (*Pseudocerastus*) *cressyi* sp. n.

(Plate IV, fig. 28; Plate VII, figs. 1–7.)

Shell rather large, turriform, subrimate in the type, but frequently imperforate, thin, silky, nearly transparent, normally corneous violet-brown. Spire produced, apex mammillate. Whorls 8, not very convex, regularly increasing, slightly bluntly angulate at the periphery, except on the last whorl of fully mature examples; the first 2 strongly and rather distantly transversely costulate, with traces of very fine, microscopic spiral striation between the ribs, remainder covered with close, regular, slightly oblique transverse costulae, which become fainter below the periphery so

* Bull. Mus. Hist. Nat. Paris, vol. xxiv, pp. 258, 259.

† Bull. Amer. Mus. Nat. Hist., vol. xl, 1919, pp. 151, 152, 158.

‡ Preston: Rev. Zool. Afric., vol. iii, 1913, pp. 53, 212.

§ See Watson: Proc. Malac. Soc., vol. xiv, 1921, p. 135.

‖ Godwin-Austen and Nevill: Proc. Zool. Soc., 1880, p. 663, pl. lxiv.

¶ Folin and Berillon: Journ. de Conchyl., vol. xxv, 1877, p. 397; Contrib. Faune Malac. Région extrême S.-O. de la France, IIIe. fasc., pp. 17–21, pls. iii, iv.

** Man. Conch (2nd ser.), vol. xix, 1908, pp. 211 *et seqq.*

†† Watson: Proc. Malac. Soc., vol. xiv, 1920, p. 26.

long as it still shows trace of keel; suture simple, well defined. Aperture subovate, peristome simple, acute; outer lip nearly straight in profile, receding slightly to the base; columella nearly white, concave in the type, with margin extremely narrowly and shortly reflexed, forming a minute rima, but very variable, as in other specimens it may be either straight or concave, and slightly truncate at the base, without marginal reflection.

Long. 22·0, lat. 8·7; apert. alt. 7·7, lat. 4·8; last whorl 12·1 mm.

Hab. L. MARQUES. District north of Macequece (Cressy).

TEXT-FIG. 20.—*Pseudoglessula* (*Pseudocerastus*) *cressyi*, Conn. Apical sculpture; ×32.

The largest specimen seen measures 26·3×9·75 mm.

The distant apical sculpture (text-fig. 22) distinguishes this fine species from all of its allies except *conradti* Mts. and *subcarinifera* Smith, both of which are smaller forms.

The fact of its live animal being available for examination renders it advisable to select as type a shell which is slightly abnormal, since the undue inflation of the outer lip causes the aperture to appear out of line with the axis, a character which, although not unusual, is not general in this species. The rimation, which in this case is of no specific value, is to some extent dependent on this inflation, as when the columella is straight

and outer lip normal there is often no trace of rimation, while the columella is frequently clearly truncate.

External features of animal.—The foot-sole is undivided. The foot-fringe is rather broad, crossed by transverse grooves, and limited above by a conspicuous peripodial groove on each side. Posteriorly the peripodial grooves curve together and unite over a caudal mucous pore, as shown in Pl. VII, fig. 2, which also shows the rounded, almost truncated, form of the posterior extremity of the foot. There is no keel. An oblique lateral groove runs forward on each side of the neck. The dorsal grooves are inconspicuous and rather close together; in front they branch into four or five well-marked vertical grooves on the front of the head. The labial palps are well developed, and the generative opening is situated rather far back on the right side of the head (Pl. VII, fig. 7).

The ground-colour of the skin is light red or salmon, this being the tint of the dermal grooves. Between the grooves, however, the rugae are more or less tinged with dark grey pigment. This dark pigment is most developed on the sides of the animal, leaving a paler dorsal area. On the neck this median dorsal area is lightest towards the edges, which are well-defined and contrast strongly with the dark lateral zones. The entire foot-sole is slightly tinged with the dark grey pigment.

The thin skin of the mantle and visceral hump is largely translucent and colourless, but it is ornamented over the lung, etc., with some vertical or oblique, irregular, brownish grey lines, which are darkest towards the suture, the broadest line being near the respiratory opening; and there are also some vertical, irregular, opaque white streaks over the exposed parts of the liver, stomach, etc. (Pl. VII, fig. 6). These white streaks are most defined and relatively largest towards the apex; and both they and the dark lines on the last whorl show clearly through the translucent brown shell.*

The mantle-edge is whitish, and is provided with the usual right and left body-lobes, the latter being divided into two widely separated portions, one near the respiratory opening, and the other on the left side of the animal.

Pallial organs.—The main pulmonary vein is without important branches, the roof of the lung only showing this single vessel passing forwards. The kidney is long, being about half the length of the lung and extending a considerable distance in front of the heart, as in *Ps. boivini*. The ureter arises from the extreme front end of the kidney, and runs back along its upper edge to the hind end of the lung; it then curves round and runs forward immediately beneath the rectum (Pl. VII, fig. 6).

Central nervous system.—In the specimen examined the cerebral

* Another specimen had more numerous dark lines and spots than the one figured.

ganglia lay above the anterior end of the buccal mass, considerably in front of the oesophagus and buccal ganglia. The arrangement of the ganglia comprised in the nerve-collar, and the relative lengths of the various connectives and commissures, will be seen from fig. 3, and present no unusual features. The otocysts are very prominent.

Digestive system.—The jaw is 1·6 mm. in length, rather thin, and very faintly transversely striated.

The radula measures $3 \times 1{\cdot}2$ mm. when flattened out. The central teeth are very narrow, and each has an extremely short single cusp (Pl. VII, fig. 1). Both the lateral and marginal teeth are bicuspid, no endocones being developed. The mesocones are large, with flanges on their inner sides; and those of the marginal teeth have somewhat rounded points. The ectocones are uniformly small but quite separate from the mesocones. The bases of the teeth are of the usual quadrate form. The transverse rows curve very slightly forwards on each side of the middle line. The radular formula is: $(26+1+27) \times 100$.

In another specimen the radula proved to be very similar, except that there were fewer transverse rows of teeth, the formula being $(27+1+27) \times 77$.

The two salivary glands are united above the alimentary canal.

Free retractor muscles.—The right and left divisions of the columellar muscle are separate practically from their origin. The right portion divides far forward into a broad ventral muscle to the foot, the so-called tail retractor and two narrower dorsal muscles, the penial retractor and the right tentacular retractor. The latter divides again into the retractor of the lower right tentacle, which passes to the left of the penis, and the retractor of the upper right tentacle, which passes between the penis and the vagina. The left division of the columellar muscle gives rise to the buccal retractor as well as to the left tentacular retractor.

Reproductive organs (Pl. VII, fig. 5).—The hermaphrodite gland consists of a rather small bunch of narrow follicles embedded in the posterior division of the liver. The hermaphrodite duct is somewhat swollen and densely convoluted throughout the greater part of its course. Close to its lower end it takes a sharp bend, and at the angle of this bend there is a very small swelling, which probably represents the vesicula seminalis. The albumen gland is rather small, tapering, and peculiarly sacculated along its sides. The common duct is large but not convoluted. The free oviduct is short. The receptaculum seminis or spermatheca lies against the common duct close to its anterior end. It is borne on a short receptacular duct with an enlarged base, which forms a continuation of the long and broad, thick-walled vagina.

The vas deferens is very slender, and is slightly convoluted near the vagina. It passes into a somewhat reniform structure, which leads into

the hinder end of the penis, and has a narrow ridge running along its posterior convex surface. This structure, like the corresponding one in the last species, is very like a short epiphallus; but it is more probable that in both species it is really a terminal appendix to the penis, and that the vas deferens does not open into it, but runs forwards embedded in its outer wall, forming the ridge mentioned above, and opens independently into the hinder extremity of the penis. It would be well, however, for any one who may have an opportunity of dissecting more full-grown specimens of either of these species to make a fresh examination of these organs by means of serial sections, so as to remove all doubt as to their exact morphology.

The penis is broad posteriorly, but tapers towards the narrower genital atrium. It is lined by longitudinal rows of small papillae, except on the ventral side towards the posterior end, where there is a thin-walled area without papillae, bounded by two thick folds which converge and meet anteriorly. The penial retractor is inserted at the junction of the vas deferens with the end of the penial appendix; it arises, as already mentioned, from the retractor of the right tentacles, and not from the diaphragm.

The head of the spermatozoon is pointed in front but somewhat swollen posteriorly, and is scarcely ·004 mm. in length. The tail is remarkably long, attaining a length of about ·37 mm.; its anterior part has a spiral structure, as shown in Pl. VII, fig. 4.

Affinities.—This species differs considerably from *Ps. boivini* in its radula (compare Pl. VII, fig. 1 with text-fig. 19), as well as in the apical sculpture of its shell, and in the character of the columella, which differs less from that found in *Pseudoglessula s. s.* than does that of *Ps. boivini.* Nevertheless the anatomical as well as the conchological characters of the present form leave little doubt that it is rightly placed in the same section of *Pseudoglessula* as the last species. It is important to notice that in both these forms the penial retractor arises from the columellar muscle, as in so many of the Achatinidae, and not from the diaphragm, as Pilsbry states that it does in *Ps. stuhlmanni* (Mts.),* a species which Germain includes in his subgenus *Pseudocerastus.*

Pseudoglessula (Pseudocerastus) gibbonsi (Taylor), 1877.

1877. *Buliminus gibbonsi* Taylor, Q.J. of C. i, p. 280, pl. 3, fig. 1. D.F.
1899 ,, *boivini* Morel., var., Smith, P.Z.S., p. 587. N.

Hab. MOZAMBIQUE (Gibbons).

L. MARQUES. Mtisherra R. Valley (Cressy).

It is with much diffidence that I assign the series from the Mtisherra

* Bull. Amer. Mus. Nat. Hist., vol. xl, 1919, p. 154.

River to this species. They are identical with a set in the British Museum from the Nyika Range, Nyasaland, which Smith considered might be a variety of *boivini*, than which, however, they are smaller, with shorter whorls. They are very distinctly, though bluntly, angled at the periphery when not quite mature, in which feature they appear to differ from *Ps. kidetensis* (Smith) and typical *gibbonsi*, while of a more obese contour than the former and with slightly more convex, gradate whorls than the latter. They are of smaller, slightly more slender form than *emini* Smith, while the whorls increase a little more slowly than in *lasti* Smith, their paries thus being more horizontal. Further series of all these so-called species are desirable before their exact inter-relationship can be determined.

Genus Homorus Albers, 1850.

Homorus manueli Preston, 1910.

1910. *Homorus manueli* Prest., Proc. Mal. Soc. ix, p. 54. D.F.

Hab. L. Marques. Mtisherra R. Valley; Zangwe Basin (Cressy); Maforga Siding (Mcdowell).

A dark brown shell with rather broad apex, originally described from Angola.

Genus Subuliniscus Pilsbry, 1919.

Subuliniscus chiradzuluensis (Smith), 1899.

(Plate V, figs. 9–16.)

1899. *Subulina chiradzuluensis* Smith, P.Z.S., p. 588, pl. 33, fig. 44. D.F.

Hab. L. Marques. District north of Macequece (Cressy).

The local race is noticeably more obese than the type set from Mt. Chiradzulu, Nyasaland, two average examples measuring $19{\cdot}8 \times 5{\cdot}8$ and $17{\cdot}5 \times 5{\cdot}7$, as against $19{\cdot}2 \times 5{\cdot}1$ and $15{\cdot}3 \times 5{\cdot}0$ mm., respectively, but the volution and sculpture appear identical, so there seems to be no reason for regarding them as distinct.

The animal is viviparous, and the anatomy differs in several respects from that characteristic of the genus *Subulina*, as will be seen from the following description. Possibly *Subuliniscus* may prove to be more nearly related to the genus *Bocageia*.

External features of the animal.—The foot-sole is undivided, and the hind end of the foot is pointed. There is no caudal mucous pore, but a peripodial groove is present, cutting off a rather narrow foot-fringe (Pl. V, fig. 13). The usual pair of dorsal grooves runs along the neck, but there is no median posterior groove or keel.

The animal is of a pale colour, except that rather small, irregular patches

of black are scattered over the skin lining the shell, chiefly in the region of the liver.

Pallial organs.—The lung is long ; its roof is very thin, and is traversed by a single pulmonary vein without any distinct branches. The kidney is about twice as long as the pericardium. The ureter arises close to the front end of the kidney and is reflexed in the manner usual among sigmurethrous snails. Pl. V, fig. 10, shows the disposition of the pericardium, kidney, and ureter in an embryo taken from the uterus.

Pedal gland.—Instead of being embedded in the muscles of the foot, the pedal gland lies just above them in the lower part of the body-cavity. It is rather long and much flattened, broad in front, but tapering gradually towards the hind end. A brown band runs along the centre of the gland and indicates the position of the duct.

Central nervous system (Pl. V, fig. 16).—The cerebral ganglia are situated above the hind end of the buccal mass. They are broader than long, and are united by a rather thick commissure, the length of which is about equal to the breadth of each ganglion. The buccal ganglia are small and are united by a commissure of about the same length as the cerebral commissure, but much narrower. The cerebro-buccal connectives are long and slender. The cerebral ganglia are united with the pedal and pleural ganglia by two pairs of rather long connectives. As usual, the pedal ganglia are the largest in the ventral group, but the abdominal ganglion is also rather large. The right parietal ganglion, although much larger than the left, is smaller than the abdominal ganglion, with which it is somewhat closely united. The remaining connectives, on the other hand, are rather long, the pleuro-pedal connectives being the longest in the ventral group.

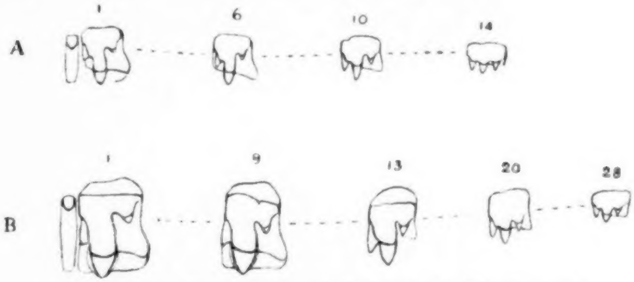
Digestive system.—The jaw (Pl. V, fig. 11) is thin, of the usual crescentic form, and about 1 mm. in length. It is crossed by numerous irregular striae or narrow folds.

The radula (text-fig. 21, B) measures about $2 \times \cdot 85$ mm. when flattened out. The central teeth are extremely narrow, with single vestigial cusps. The lateral and marginal teeth are tricuspid, with quadrate bases. The mesocones are large in the lateral teeth, but become smaller in the marginals. The ectocones are uniformly small, but are always quite separate from the mesocones. The endocones are also small, and in the lateral teeth they become more or less united with the mesocones, from the sides of which they appear to spring. The transverse rows of teeth curve slightly forwards on each side of the middle line. The formula of the specimen examined is $(32+1+32) \times 102$.

The embryonic radula (text-fig. 21, A) measures about $\cdot 8 \times \cdot 35$ mm., and its formula is $(17+1+17) \times 68$. The individual teeth are also smaller in the embryo, and a little broader in proportion to their length. The central

teeth, however, are relatively not quite so small as in the adult. The cusps of the other teeth are slightly narrower than they are in the full-grown radula, and the endocones are a little more distinct.

The radula of this species differs from those of *Subulina octona* (Brug.) and allied forms chiefly in the very inconspicuous endocones of the lateral teeth. Since, however, the ndocones are more prominent in the marginal teeth, and are rather better developed in the embryo than in the adult, it seems likely that this species has been evolved from a form having the more obviously tricuspid lateral teeth found in most of the Stenogyrinae. The particularly degenerate central teeth also suggest that in its radula this species is less primitive than many of its allies.



TEXT-FIG. 21.—*Subulina chiradzuluensis* (Smith), Macequece.

A. Representative teeth from the radula of an embryo from the uterus; ×600.
B. Representative teeth from the radula of a mature specimen; ×600.

The course of the alimentary canal will be seen from Pl. V, fig. 14. The crop is unusually narrow, but perhaps this may be due to the relatively large embryos swelling the genital ducts to such an extent as to leave little room for the other organs in this region. The salivary glands are long, and are situated a little further forward than usual. They are united with each other above the alimentary canal.

Free retractor muscles (Pl. V, fig. 15).—The columellar muscle divides not far from its origin into a right and left division. A little further forward the right division gives off a broad "tail retractor" to the foot. The remaining portion of the muscle runs forward as the right tentacular retractor, but just before it divides into the retractors of the upper and lower tentacles, it gives rise to the penial retractor, which, as in most members of this family, does not arise from the diaphragm. The muscles going to the lower tentacle and the front of the head pass to the left of the penis, but the retractor of the right upper tentacle passes between the penis and the vagina.

The left division of the columellar muscle divides rather far forward

into the buccal retractor and the left tentacular retractor, and the latter again divides into branches going to the upper and lower left tentacles and to the front of the head. The asymmetrical origin of the buccal retractor is probably not a primitive feature, as this muscle is innervated by a symmetrical pair of nerves, that to the right side of the retractor arising from the right cerebral ganglion, and that to the left side from the left ganglion.

Although the outer skin of the upper tentacles seems to be devoid of pigment, the retractors of these tentacles are pigmented in the usual manner, which does not appear to be the case in the genus *Subulina*.

Reproductive organs (Pl. V, fig. 15).—The follicles of the hermaphrodite gland are embedded in the posterior division of the liver. The hermaphrodite duct is but slightly swollen and convoluted. No vesicula seminalis was found, unless it is represented by a slightly enlarged and abruptly convoluted portion of the duct close to the albumen gland. The uterine part of the common duct is greatly swollen by the presence of the relatively large embryos within it. One of these embryos is shown in fig. 9. They measure about $3\frac{1}{2} \times 2$ mm., and three of them were found in the uterus of one adult snail, and five in another. As they were not enclosed in any egg-shells, there can be little doubt that this species is viviparous.

The receptaculum seminis or spermatheca is rather small, and lies close to the common duct towards its anterior end; it is borne on a slender receptacular duct of moderate length. The free oviduct is very short, but the vagina is decidedly long, though rather narrow. The genital atrium or vestibule is very short. The vas deferens is slender, and enters the hinder end of the penis beside the insertion of the penial retractor. There is no distinct epiphallus. The penis is rather narrow near the genital atrium, but is broad posteriorly; and although it is of no great size, it is not nearly so small as in *Subulina octona*.*

The spermatozoa have small heads, and very long slender tails, with a spiral filament or flange near the anterior end (Pl. V, fig. 12).

Genus Curvella Chaper, 1885.

Curvella nyasana Smith, 1899.

1899. *Curvella nyasana* Smith, P.Z.S., p. 588, pl. 33, fig. 44. D.F.

Hab. L. Marques. District N. of Macequece, 4500 ft.; Mtisherra R. Valley (Cressy).

This species was described from Mt. Chiradzulu, other Nyasaland localities being Zomba, Masuku Plateau, and the Nyika Range. The series

* See Wiegmann, Beiträge z. Anat. d. Landschnecken d. Indischen Archipels (in Zool. Erg. Niederländisch Ost-Indien, vol. iii.), 1892, pl. xvi, fig. 3.

differ slightly in size and contour, the type set being more slender and that from Zomba more obese, but there is not sufficient difference to merit even varietal distinction between any of them. The shells from Portuguese territory resemble those from Zomba in being larger and slightly more obese than the type, but are quite conspecific with it.

Curvella disparilis (Smith), 1890.

1890. ***Bulimus*** (***Hapalus***) *disparilis* Smith, A.M.N.H. vi, p. 156, pl. 5, fig. 13. D.F.

Hab. L. Marques. Mtisherra R. Valley; Dondo District; Zangwe Basin (Cressy).

Described from Mamboia and also recorded from Usagara, both localities in Tanganyika Territory.

Curvella quisqualis (M. and P.), 1892.

1892. ***Buliminus quisqualis*** M. and P., A.M.N.H. ix, p. 90, pl. 5, fig. 10. D.F.

Hab. Mozambique (Layard).

Genus Euonyma M. and P., 1896.

Euonyma lanceolata (Pfr.), 1854.

1854. *Bulimus lanceolatus* Pfr., P.Z.S., p. 292. D.

1910. *Euonyma lanceolata* Pfr., Conn., A.M.N.H. vi, pp. 260–261. N.F.

Hab. L. Marques. Near Delagoa Bay (in British Museum).

Euonyma crystallina (M. and P.), 1896.

1896. *Subulina crystallina* M. and P., A.M.N.H. xviii, p. 316, pl. 16, fig. 4. D.F.

Hab. Lebombo Marsh, Rikatla (Junod); Masiene (Lawrence).

Specimens from the above localities are quite in agreement with this common Natalian species, whose extension northward along the coast is by no means remarkable.

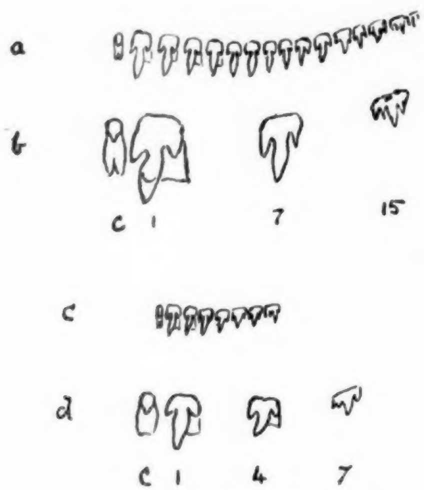
Genus Opeas Albers, 1850.

Opeas praecox sp. n.

(Plate IV, fig. 25.)

Shell of fair size, elongate turriform, narrowly rimate, thin, smooth, glossy, transparent, pale olivaceous. Spire produced, apex narrowly

rounded. Whorls 8, rather flat, regularly increasing, the first 2 practically smooth, remainder sculptured with rather faint, close, fairly regular, curved vertical striae; suture simple, shallow. Aperture subpiriform, peristome simple, acute, outer lip projecting rather sharply forward for about $1\frac{1}{4}$ mm., at which point it is slightly sinuate, and then receding more gently to the base; columella very slightly concave, not truncate, margin very narrowly reflexed, nearly concealing the narrow rima.



TEXT-FIG. 22.—*Opeas praecox* Connolly, Zangwe Basin, Portuguese E. Africa.
a, $\frac{1}{2}$ row of radula of immature but fertile specimen; $\times 300$ (approx.)
b, Individual teeth enlarged.
c, $\frac{1}{2}$ row of radula of embryo; $\times 300$ (approx.).
d, Individual teeth enlarged.

Long. 11·3, lat. 3·0; apert. alt. 3·0, lat. 1·2; last whorl 5·0 mm.

Hab. L. MARQUES. Zangwe River Basin (type, Cressy).

NYASALAND. Port Herald Hills (Harger).

A puzzling species, varying considerably in contour of spire and slightly in length of whorl between sutures, the type being more slender and slightly shorter-whorled than other individuals, whose greater breadth imparts to them rather a different aspect. However, a considerable series from the type locality exhibits every stage of transition, and some of these exactly match some of those from Port Herald, while others from the latter district show still further slight variation.

Colonel Peile has kindly furnished drawings of the radula (text-fig. 22).

Opeas vengoense Conn., 1922.

(Plate IV, fig. 26.)

1922. *Opeas vengoense* Conn., A.M.N.H. x, p. 120. D.

Hab. L. MARQUES. Mount Vengo, 5500 ft. (Cressy).

A minute shell, occurring at considerable depth in decaying vegetation. Its smaller form and comparatively longer last whorl distinguish it from the young of the next species.

Opeas cressyi Conn., 1922.

(Plate IV, fig. 27.)

1922. *Opeas cressyi* Conn., A.M.N.H. x, p. 120. D.

Hab. L. MARQUES. District N. of Macequece (Cressy).

The beautiful little shell selected as type measures long. 10·8, lat. 2·8; apert. alt. 3·3, lat. 1·2; last whorl 5·7 mm. It is the largest of a bewildering series which may eventually prove to contain more than one species. Egg-holding, and therefore nearly mature, shells range from the type downwards to a length of only 5 mm., while individual examples appear to differ in relative convexity of whorl, distance between sutures, and closeness and depth of striation. There seem, however, to be such exact intermediates between each extreme that I can only conclude that they are all members of one species and that the variation is due partly to local conditions of food and weather and partly, perhaps, to individual reversion to earlier and more distinct types, of whose promiscuous interbreeding the present confused race is the result.

I append rather a lengthy table of measurements of certain specimens, as it appears advisable to show the convergence between extremes of form.

Long.	9·2;	lat.	2·8;	apert.	3·1;	last whorl	5·2	mm.
,,	9·2;	,,	2·3;	,,	3·1;	,,	5·0	,,
,,	9·0;	,,	2·5;	,,	2·9;	,,	4·9	,,
,,	8·8;	,,	2·5;	,,	3·2;	,,	4·9	,,
,,	8·5;	,,	2·6;	,,	3·0;	,,	5·3	,,
,,	8·3;	,,	2·2;	,,	3·0;	,,	4·8	,,
,,	8·0;	,,	2·7;	,,	3·2;	,,	4·9	,,
,,	7·8;	,,	2·45;	,,	2·75;	,,	4·3	,,
,,	6·9;	,,	1·95;	,,	2·3;	,,	4·0	,,
,,	6·4;	,,	2·15;	,,	2·55;	,,	4·3	,,
,,	5·75;	,,	1·95;	,,	2·50;	,,	3·8	,,
,,	5·4;	,,	1·7;	,,	2·25;	,,	3·5	,,

FAMILY FERUSSACIIDAE.

Genus CAECILIOIDES Férussac, 1817.

Caecilioides ovampoensis (M. and P.) 1892.

1892. *Cionella ovampoensis* M. and P., A.M.N.H. ix, p. 91, pl. 6, fig. 1. D.F.

Hab. L. MARQUES. Matolla (Penther).

I have not seen Penther's shells and have no idea to what species they really belong. Cressy has collected on Mount Vengo specimens of this genus which appear to be quite distinct from *C. acicula* (Müll.) or from any of the African so-called species, but the material so far received from him is not quite sufficient for its exact determination.

FAMILY SUCCINEIDAE.

Genus SUCCINEA Draparnaud, 1801.

Succinea normalis Ancey, 1881.

1881. *Succinea normalis* Ancey, Le Naturaliste, i, p. 484. D.
1923. „ „ „ Dup. and Putz., Ann. Soc. Zool. Belg. liii, p. 72, fig. 6. D.F.

Hab. Interior of MOZAMBIQUE (fide Ancey).

Founded on a single specimen.

Succinea patentissima Mke., 1853.

1854, 55. *Succinea patentissima* Mke., Pfr., Conch. Cab., p. 55, pl. 6, figs. 26–28. D.F.

Hab. L. MARQUES. Lebombo Marsh, Rikatla (Junod); Wanetsi R., Magude District (Bell Marley).

Succinea striata Krauss, 1848.

1848. *Succinea striata* Krs., Südafr. Moll., p. 73, pl. 4, fig. 16. D.F.
1856. „ *planti* Pfr., P.Z.S., p. 326. D.

Hab. L. MARQUES. Lebombo Mts., under bark of shrubs (Junod); Lake Zandemela (Lawrence).

The type set of *planti* in the British Museum are simply very immature examples of *striata*, which is partial to so many dry and exposed positions that it is far more often found in an immature than a mature stage of growth.

FAMILY VERONICELLIDAE.

Genus VERONICELLA de Blainville, 1817.

Veronicella maura (Heynem.), 1885.

1885. *Vaginula maura* Heynem., Jahrb. D. Mal. Ges. xii, pp. 7, 104, pl. 1, figs. 6–7. D.F.

Hab. L. MARQUES. Delagoa Bay (Mrs. Monteiro).

Veronicella natalensis (von Rapp), 1848.

1848. *Vaginulus natalensis* von Rapp, Krs., Südafr. Moll., p. 72. D.

Hab. MOZAMBIQUE (var., Gibbons).

Veronicella petersi (Mts.), 1879.

1879. *Vaginula petersi* Mts., Monatsb. Akad. Wiss. Berlin, p. 736. D.

Hab. MOZAMBIQUE. Querimba I. (Peters).

L. MARQUES. Inhambane (Peters).

FAMILY ONCHIDIIDAE.

Genus ONCHIDIUM Buchanan, 1800.

Onchidium peroni Cuv., 1804.

Onchidium peronii Cuv., Ann. Mus. Nat. Hist. Paris, v, p. 38, pl. 6, figs. 1–9. D.A.

Hab. MOZAMBIQUE. Mozambique ; Ibo (Peters).

L. MARQUES. Inhambane (Peters).

FAMILY AURICULIDAE.

SUBFAMILY MELAMPINAE.

Genus MELAMPUS Montft., 1810.

Melampus caffer (Küst.), 1844.

1844. *Auricula caffra* Küst., Conch. Cab., p. 36, pl. 5 (1843), fig. 7. D.F.

Hab. L. MARQUES. Estuary of Nkomati River, Rikatla (Junod).

Melampus semiaratus Conn., 1912.

1912. *Melampus semiaratus* Conn., Ann. S. Afr. Mus. xi, p. 228, pl. 2, fig. 8. D.F.

Hab. L. MARQUES. Estuary of Nkomati River, Rikatla (Junod).

Melampus küsteri (Krs.) var. *oblongus* Küst., 1844.

1844. *Auricula küsteri* Krs., var. *oblonga* Küst., Conch. Cab., p. 34. D.
Hab. L. MARQUES. Estuary of Nkomati River, Rikatla (Junod).

The foregoing names are correctly applied to the three forms of *Melampus* from the above locality; but whether the names are good in themselves, or should be merged in the synonymy of older ones, is open to question.

While nearly every species of this genus seems to vary so greatly that each combines the distinctive attributes of others, certain forms which appear almost, if not absolutely, identical in all conchological characters occur throughout nearly the whole expanse of the Pacific and Indian Oceans, so that names originally bestowed on Philippine species have been applied to South African, and *vice versâ*.

Whether such a distribution is possible can only be determined by the anatomist, but it seems so improbable that I prefer to retain, for the present, the names originally created for African species.

SUBFAMILY AURICULINAE.

Genus AURICULASTRA von Martens, 1880.

Auriculastra acuta Conn., 1922.

(Plate IV, fig. 29.)

1922. *Auriculastra acuta* Conn., A.M.N.H. x, p. 121. D.
Hab. L. MARQUES. Estuary of Nkomati River (Junod).
Type in Kimberley Museum.

Auriculastra acuta is found in company with the three *Melampi* in the mangrove region in the estuary of the Nkomati River, which can only be approached on foot at low tide, when the mud is exposed and its surface covered by thousands of crabs. Immature examples of all four species were collected alive on the mud under rotten stems, but larger shells were only found in dead condition on its seaward boundary, where they appeared to have been left by the tide.

The type measures $17{\cdot}8 \times 8{\cdot}0$ mm., and three other examples $17{\cdot}6 \times 7{\cdot}2$, $16{\cdot}1 \times 6{\cdot}2$, and $8{\cdot}8 \times 3{\cdot}8$ mm. respectively.

In all stages of growth the spire of this species is comparatively longer than that of any other African member of the genus.

FAMILY LIMNAEIDAE.

Genus LIMNAEA Lam., 1799.

Limnaea natalensis Krs., 1848.

1848. *Limnaeus natalensis* Krs., Südafr. Moll., p. 85, pl. 5, fig. 15. D.F.
Hab. MOZAMBIQUE. R. Quilimane (Peters).

L. MARQUES. Itschongove (fide von Martens); Lebombo Marsh, Rikatla (a small, acuminate form, somewhat comparable to *L. undussumae*, Mts.); L. Mhandlen; Makulane (Junod).

When we consider the range of variation which is acknowledged in such European species as *Limnaea pereger* and *L. truncatula* without, in many cases, even a varietal name being considered necessary, it is evident that far too many specific names have been bestowed on forms of the African *L. natalensis* which are less worthy of varietal rank than many that occur in the European species. I have not, therefore, attempted to fit any such names to the shells from the above-mentioned localities, which differ a little in comparative breadth and contour, but are certainly not varietally distinct from one another.

FAMILY PHYSIDAE.

Genus PHYSA Draparnaud, 1801.

Physa mosambiquensis Clessin, 1886.

1886. *Physa mosambiquensis*, Cless., Conch. Cab., p. 366, pl. 54, fig. 4. D.F.

Hab. L. MARQUES. Tette (Peters).

The subjoined outline, representing the largest example in the Berlin Museum, has been kindly furnished by Dr. Thiele, who informs me that the radula confirms the appearance of the shell as being that of a true *Physa*; a

TEXT-FIG. 23.—*Physa mosambiquensis* Clessin; ×2.

most interesting fact, since only one other species of this genus, *Physa waterloti*, Germain,* has hitherto been recorded from Central or South Africa.

I may mention, however, that I have in my hands for description the shell of a third species, unmistakably that of a *Physa*, from Lake Naivasha.

P. waterloti, originally recorded from Dahomey, has since been collected by Dr. J. W. S. Macfie, of the Liverpool School of Tropical Medicine, at Accra, Gold Coast.

* Bull. Mus. Paris, 1911, p. 322.

Family PLANORBIDAE.

Subfamily ISIDORINAE.

Genus Isidora Ehrenberg, 1831.

I retain this name provisionally in preference to *Bulinus* of Müller because the type of *Isidora* is a known species, whereas no authentic examples of *Bulinus senegalensis* Müller are in scientific circulation. As soon as recognisable topotypes of the latter come to hand, Müller's genus-name will undoubtedly supersede some other, but until they are rediscovered it appears inadvisable to introduce it too hastily into current nomenclature.

Isidora natalensis (Krs.), 1841.

1841, '43. *Physa natalensis* Krs., Küst., Conch. Cab. (Limn.), p. 8, pl. 1, figs. 12–14. D.F.

Hab. L. Marques. Lebombo Marsh, Rikatla; Monguane; Makulane (Junod); Beira (Cawston); L. Zandemela (Lawrence).

The examples from the last two localities are very dwarfed.

Isidora forskali Ehrn., 1831.

1831. *Isidora forskalii* Ehrn., Symb. Phys., Evert. 3rd sp. D.
1848. *Physa wahlbergi* Krs., Südafr. Moll., p. 84, pl. 5, fig. 13. D.F.
Hab. Mozambique. Quilimane (Stuhlmann).
L. Marques. Beira (Cawston).

Subgenus physopsis Krauss, 1848.

Krauss differentiated his *Physopsis africana* generically from other South African species of *Isidora* simply because the latter are perforate, without columellar truncation, while *P. africana* was imperforate, with truncate columella. Although the columella of *Physopsis*, however, is always more or less truncate, the absence of perforation is of no generic value, since even in *africana* clearly perforate examples may be sometimes, though very seldom, found, while other species, such as *globosa* Morelet, are almost invariably perforate. As pointed out hereinafter by Watson, the anatomy of *Physopsis* does not afford sufficient ground for generic distinction from *Isidora*, and it appears more rational to treat it as a subgenus of the last named, separable therefrom by reason of its more or less truncate columella.

Isidora (Physopsis) africana (Krs.), 1848.

1848. *Physopsis africana* Krs., Südafr. Moll., p. 85, pl. 5, fig. 14. D.F.

Hab. L. Marques. Tette (Peters; Kirk; Penther); Lebombo Marsh, Rikatla (Junod); Wanetsi R., Magude District (Bell Marley).

It is possible that some of the foregoing records refer in reality to the succeeding species.

Isidora (Physopsis) globosa (Morelet), 1866.

(Plate VIII, figs. 8–15.)

1868. *Physopsis globosa* Morel., Voy. Welwitsch, p. 93, pl. 9, fig. 4. D.F.

Hab. L. Marques. Lebombo Marsh, Rikatla (Junod); Delagoa Bay (Cawston).

The range of this very variable species extends laterally across the continent from Angola, through Rhodesia and Nyasaland, to Delagoa Bay. Some Delagoan examples correspond well with Morelet's type, while others differ considerably *inter se* in length of spire and form of aperture, but all appear to be conspecific. In addition to the slight difference in the radula mentioned later, the shell is practically always to some extent rimate, and can thus be separated without much difficulty from *I. (Physopsis) africana* (Krs.).

External features of animal and pallial organs.—The foot is broad and bluntly pointed at the hind end. The tentacles are slender and rather long, with the eyes situated at their inner bases (Pl. VIII, fig. 13). At their outer bases there is a rounded, flattened lobe on each side, such as was first described by Adanson in *Bulinus senegalensis* Müll.* The male opening is situated beneath the posterior corner of the lobe on the left side; the female opening is under the mantle-edge.

The orifice of the mantle-cavity is large (Pl. VIII, fig. 8). At its inner or right side, posterior to the anus, there is a large grey pallial lobe, which is thrown into numerous vertical folds, the bigger folds being subdivided by smaller ones. This is the characteristic folded gill of the genus *Isidora*, which is found not only in the various African members of the genus, but also in those occurring in Madagascar, Tasmania, New Zealand, etc.,† as well as in the related genus *Miratesta* from Celebes.‡ Anterior to the anus there is a simple, less prominent, white lobe, which forms the lip of the so-called pulmonary siphon.

The head and foot are rather light grey, the hind end of the foot and the top of the head being the darkest. The mantle-edge is pale, but the roof

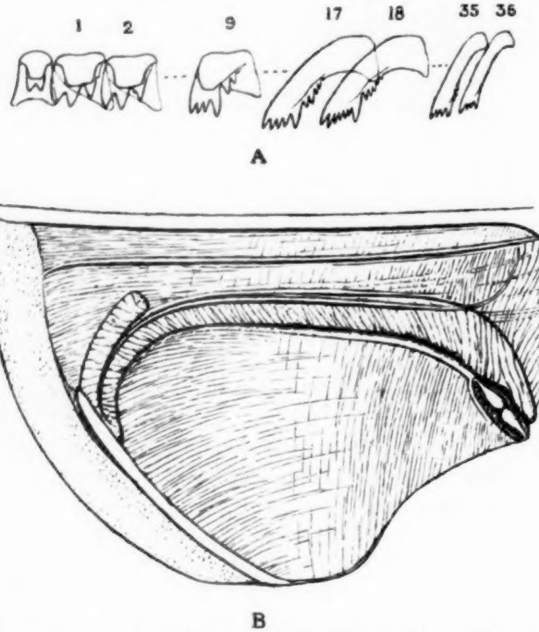
* Hist. Nat. du Sénégal, Hist. des Coquillages, 1757, p. 6, pl. i, fig. J *g*.

† Pelseneer: Arch. de Biol., vol. xiv, 1896, pp. 365, 372, pl. xv, figs. 10–11.

‡ Sarasin: Die Süsswasser Mollusken von Celebes, 1898, p. 76, pl. xii, figs. 165–166.

of the mantle-cavity is covered with numerous dark spots on a light grey ground. In some cases these spots are nearly black; in others they are lighter and only clearly visible near the mantle-edge.

The kidney is long and narrow and extends forwards from above the heart to the mantle-edge just below the pulmonary orifice, where it curves



TEXT-FIG. 24.—*Isidora* (*Physopsis*) *globosa* (Morel.), Lorenzo Marques.
A. Representative teeth from the radula; ×400.
B. Roof of mantle-cavity seen from within, showing kidney, etc. (slightly diagrammatic); ×7.

downwards, and then abruptly bends round and runs back above its former course to the renal opening, which thus faces backwards about 2 mm. within the pulmonary orifice (text-fig. 24, B). The kidney is therefore of the same type as in *Isidora lamellata*, Smith.* As in that species an afferent renal vein runs back most of the way along the dorsal edge of the kidney, while another vein conveying blood from the kidney to the heart runs along its lower edge. This vessel receives a small pericardial vein just before it reaches the heart, but the network of pulmonary veins which Pelseneer shows beneath the kidney in *I. lamellata* is not apparent in the present

* Pelseneer: *op. cit.*, p. 370.

species. A prominent fold runs along the roof of the mantle-cavity about half-way between the kidney and the rectum, and opposite this there is a similar fold on the rectum itself, the front end of which can be seen below the branchial lobe in Pl. VIII, fig. 8. These folds are also found in related forms. But in the present species, and also in *I.* (*Physopsis*) *africana* (Krs.), another thickened ridge occurs, which runs along the kidney near its upper edge and curves upwards posteriorly on to the roof of the mantle-cavity, where, however, it becomes so low as to be scarcely perceptible. Opposite to this ridge on the kidney there is a slight thickened ridge along the lower edge of the rectum. These two ridges correspond to the much larger ridges which occur in the same positions in *Planorbarius corneus* (Lin.), but they do not seem to occur in the more typical species of *Isidora* such as *I. forskali* Ehrn., *I. contorta* (Mich.), *I. tropica* (Krs.), and *I. lamellata* (Smith). Indeed, the presence of these longitudinal ridges in the mantle-cavity, in addition to the pair of folds above them, seems to be the one marked anatomical feature which distinguishes the subgenus *Physopsis* from *Isidora s.s.*

Central nervous system (Pl. VIII, fig. 9).—The nerve-ring is situated behind the buccal mass, and is very small, the cerebral, pedal, pleural, and visceral ganglia being all closely aggregated owing to the exceptional shortness of the connectives that unite them. The arrangement of these ganglia agrees well with that in *I. lamellata*,* but the left parietal ganglion has a well-marked lateral lobe, external to the origin of the left pallial nerve, which Pelseneer does not show in his figure of the nervous system of that species. The buccal ganglia are moderately large, and are united by a commissure about equal in length to the greatest diameter of the ganglia. Laterally, at their junction with the cerebro-buccal connectives, they each give off two large nerves to the sides of the buccal mass; in front there arise two or three slender nerves to the oesophagus, salivary glands, etc.; while the odontophoral nerves arise at the inner sides of the ganglia, near the ends of the buccal commissure.

Digestive system.—The dorsal jaw is rather thick and dark brown, with an obtuse median projection and fine vertical striae. It measures about ·9 mm. in length, and nearly ·4 mm. broad in the centre, though much narrower towards the ends. The lateral jaws are narrow and weak, and of a much lighter colour.

The radula (text-fig. 24, A) is of the type found not only in *Isidora*, but also in *Miratesta*, *Protancylus*, *Planorbarius*, *Carinifex*, etc. The central teeth are bicuspid, and rather narrow. The lateral teeth, of which there are eight or nine on each side, are broader, and tricuspid, with triangular basal plates; in some of them, however, the ectocone already shows a tendency to divide. There are about thirty-six multicuspid marginal

* Pelseneer: *op. cit.*, p. 369, pl. xvi, fig. 19.

teeth on each side, in which both the endocones and the ectocones are split up into a number of small cusps. The relative length of the teeth gradually increases towards the edges of the radula, and the outer marginals are very narrow with scarcely a trace of the ectocones. The transverse rows of teeth curve slightly forwards on each side. The radula of the present species differs from those of *I.* (*Physopsis africana* and other forms chiefly in the relative narrowness of the outer marginal and central teeth, and the extent to which the ectocones of the marginal teeth are split up into separate cusps.

The salivary glands are very long, narrow, and somewhat convoluted (Pl. VIII, fig. 12). They arise directly from the broad buccal mass on each side of the anterior end of the oesophagus, without the interposition of distinct slender ducts. They are broadest a short distance from their front ends; further back they have a moniliform appearance, being divided by constrictions into a succession of small swellings. The glands pass through the nerve-ring, becoming exceedingly narrow as they do so; but the greater part of each gland lies in front of the central nervous system.

The oesophagus is long and rather narrow, with thin walls which usually show longitudinal lines of dark pigment. The anterior division of the stomach is spherical, with thick muscular walls, and contains grains of sand. The succeeding thin-walled portion of the stomach is much narrower, and bends downwards on the right, where there open into it together the broad hepatic duct and the so-called pyloric caecum, a finger-shaped appendage scarcely 2 mm. in length, like that which is found in most Basommatophora. The intestine curves round the stomach, passing over the oesophagus as it does so, and then describes another loop among the lobes of the liver, before passing forwards as the rectum. The liver lies entirely behind the stomach.

Chief retractor muscles.—The columellar muscle is broad and powerful; its central part is inserted in the foot, while its more lateral strands pass forwards to the sides of the head. From its upper surface arise the rather narrow buccal and penial retractors.

Reproductive organs (Pl. VIII, fig. 14).—The reproductive system is of the same general type as that found in the other species of *Isidora* which have been examined. The hermaphrodite gland is compact, and occupies the apex of the spire posterior to the liver. The hermaphrodite duct is somewhat convoluted, especially in the posterior half of its course, where it is covered with very numerous small vesicular outgrowths. The albumen gland is rather large. The oviduct, which is separate from the male duct throughout its length, is divisible into two parts—a posterior portion which is convoluted and rather narrow and an anterior portion which is more glandular and greatly swollen. An oblique line crosses this anterior portion, the part behind and to the left of the line being trans-

lucent, while that in front and to the right of it is opaque and whitish in alcohol. The receptaculum seminis or spermatheca is broadly oval and nearly 2 mm. long, with very thin walls, and is borne on a short duct. The vagina is rather short.

The vas deferens runs forwards beside the oviduct, and is somewhat convoluted in the posterior part of its course. It bears a nearly circular compact prostate gland, which is situated between the glandular part of the oviduct and the spermatheca, being slightly flattened by the pressure of these organs. The vas deferens passes into the skin beside the female opening, and emerges again into the body-cavity near the male opening, whence it passes backwards to the penis. This organ is nearly three times as broad as the slender vas deferens, and leads into the large penis-sac, which is in turn three times as broad as the penis itself, both organs being nearly 4 mm. in length. The penial retractor is inserted at the junction of the penis and the penis-sac. The end of the penis next to the vas deferens is somewhat swollen ; this is due to the fact that the terminal part of the vas deferens is either contorted within the muscular penis-sheath before opening into the penis itself, as shown in Pl. VIII, fig. 11, or else it is invaginated into the cavity of the penis to form a penis-papilla, as shown in fig. 15. The epithelium lining the penis is furnished with numerous small papillae. Inside the penis-sheath there are two longitudinal folds, approximately opposite to each other, and numerous narrower transverse or circular folds. The positions of the longitudinal folds, and to some extent those of the transverse ones also, are shown by dark lines of pigment on the outside of the penis-sheath. The anterior end of the penis is often invaginated for some distance into the cavity of the penis-sheath.

The spermatozoa (Pl. VIII, fig. 10) have short, spirally twisted heads, ·0033 mm. in length, broad behind but sharply pointed in front. The tails attain a length of more than ·25 mm., and appear to be furnished throughout almost their entire length with two narrow spiral flanges or ridges, which, however, are most distinct close to the head, where one of them becomes markedly broader, as shown in the figure.

Subfamily PLANORBINAE.

Genus Planorbis Geoffroy, 1767.

Subgenus PLANORBULA Haldemann, 1842.

Planorbis (*Planorbula*) *pfeifferi* Krs., 1848.

(Plate VIII, figs. 16–19.)

1848. *Planorbis pfeifferi* Krs., Südafr. Moll., p. 83, pl. 5, fig. 7. D.F.

1899. *Planorbis rüppelli*, "Krs.," Junod, Bull. Soc. Vaudoise, xxxv, p. 279. L.

Hab. L. MARQUES. Itschongove (fide von Martens); Lebombo Marsh, Rikatla (*rüppelli*); Nyiwan; gardens, Lorenzo Marques; Makulane (Junod).

Long series of large *Planorbes* from the above localities have all proved identical with *Plan. pfeifferi* Krs., and it may be accepted that the inclusion of the Abyssinian *Plan. rüppelli* in Junod's list was due to misidentification; the latter species can therefore be removed from the local and South African lists.

Burnup is the first to have observed that at a certain stage in the growth of *Plan. pfeifferi* the aperture is occasionally denticulate, resembling in this respect that of *Plan. alexandrinus* Ehrn. This phase seems to be most prevalent in examples about 6 mm. in diameter, but is of extremely rare occurrence, a very large number of specimens examined having so far only yielded half a dozen showing the dentition, which appears to become absorbed in more mature shells. Its arrangement is pretty constant in the only 4 examples I have seen. It consists of a small plait in the centre of the paries, with a minute tubercle below it, and 3 small horizontal plaits, of which the lowest is the most prominent, at nearly equal intervals apart, on the interior of the last whorl some distance within the aperture; in one case there is a 4th, very small plait above the others. These 4 shells measure between 5½ and 6 mm. in diameter and hail from such interdistant localities as Umbogintwini, Natal (Burnup); near Victoria Falls, Rhodesia (Soper) and Rikatla (Junod).

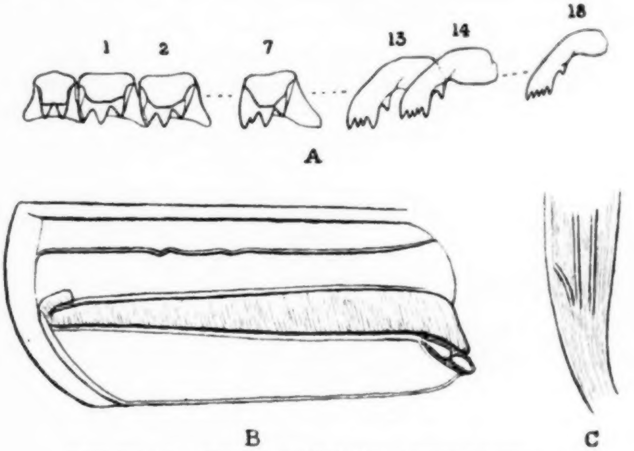
This particular dentition is identical with that sometimes found in *Planorbula alexandrina* (Ehrn.), but in the latter the dentition is far more usual in the immature stage of growth, and is subject to so much variation that it is impossible to deal with it further in this paper.

External features of animal and pallial organs.—The animal is grey, except for a varying number of irregular patches of deep black pigment on the roof of the mantle-cavity. The foot is rather broad, and rounded at the hind end. The eyes are at the inner bases of the tentacles, which are long and slender, with a semicircular flattened lobe on each side at their outer bases. The male opening is situated at the posterior corner of the lobe on the left side, while the female opening is beneath the broad mantle-edge.

Below the orifice of the mantle-cavity, which is situated towards the left side of the animal, there is a broad lobe incompletely divided into two portions (Pl. VIII, fig. 17). The right-hand portion is broadly rounded, and of a paler colour than the other; it forms the lip of the so-called pulmonary siphon. The left-hand portion projects further, and is bluntly pointed; it constitutes the branchial lobe. It is not folded transversely as in *Isidora*, but bears a longitudinal fold on its upper surface, which is a continuation

of the fold on the rectum inside the mantle-cavity described below. The anus is situated to the right of this fold on the top of the lobe.

The kidney is long, rather narrow, and nearly straight except at its front end, which, on reaching the mantle-edge immediately below the pulmonary orifice, bends round abruptly, in the manner shown in text-fig. 25, B. An afferent renal vein runs back along the left edge of the kidney, and another vein conveying blood from the kidney to the heart passes along beside its right edge. No thickened ridge runs along the kidney as



TEXT-FIG. 25.—*Planorbis pfeifferi* Krs., Lorenzo Marques.

A. Representative teeth from the radula; ×500.
B. Roof of mantle-cavity seen from within, showing kidney, etc. (slightly diagrammatic); ×8.
C. Columellar muscle, with buccal and penial retractors arising from it; ×8.

in *Planorbarius corneus* (Lin.); but between the kidney and the rectum there is a longitudinal fold on the roof of the mantle-cavity, such as we also find in *Planorbarius* and *Isidora*. Opposite to this a similar fold runs along the rectum, curving to the left as it reaches the anus and continuing to the extremity of the branchial lobe.

Central nervous system.—The arrangement of the principal nerve-ganglia resembles that in *Isidora*, *Planorbarius*, and *Physa*,* the nerve-ring being small and the connectives almost as short as in *Isidora* (*Physopsis*) *globosa* (Morel.) (Pl. VIII, fig. 9), although the lateral lobe of the left parietal ganglion is not quite so distinct as in that species The nerve-ring is situated behind the buccal mass, and the buccal ganglia are a little

* See de Lacaze-Duthiers: Arch. Zool. Expér. et Gén., vol. i, 1872, pls. xix, xx.

distance behind the anterior end of the oesophagus. These ganglia are rather large, rounded, and joined by an unusually short buccal commissure.

Digestive system.—The dorsal jaw measures about ·45 mm. long, by nearly ·2 mm. broad in the centre. Its upper margin is arched, while its lower cutting edge is somewhat irregular. It is moderately thick, with faint vertical striae, and is of a brown colour. The lateral jaws are of about the same length as the dorsal jaw, but are narrower and thinner.

The radula (text-fig. 25, A) measures about $1·65 \times ·65$ mm. when flattened out. The central teeth are bicuspid, and about as broad as they are long. The lateral teeth are broader and tricuspid, the cusps of both central and lateral teeth being rather short in the specimens from Lorenzo Marques, although they are a little longer in examples from near Durban which in other respects agree closely with those from Portuguese East Africa. The marginal teeth are obliquely elongated, their endocones are split up into three or four narrow cusps, and their ectocones tend to become smaller. They are of the same type as the marginal teeth of *Planorbarius*, *Isidora*, etc., and differ widely from those of *Planorbis s.s.* and *Segmentina*. The transverse rows of teeth curve slightly forwards on each side. The radular formula is: $(13+8+1+8+13) \times 125$.

The salivary glands are long, rather narrow, and somewhat contorted (Pl. VIII, fig. 19). They do not pass through the nerve-ring, but unite with each other at their posterior ends. The oesophagus is long and narrow, though sometimes a little swollen near its anterior end. The stomach, which contains grains of sand, is rather short, the anterior part with thick muscular walls being much broader than long. The thin-walled posterior division of the stomach bends downwards, and gives off at its lower end the hepatic duct and the small finger-shaped "pyloric caecum," which is about 1 mm. long. The intestine encircles the stomach, and then describes another loop behind it among the lobes of the liver, before passing forwards as the rectum.

Chief retractor muscles (text-fig. 25, C).—The columellar muscle is broad, and passes forwards to the foot and the sides of the head. About the middle of its length it gives off from its upper surface the two rather narrow buccal retractors, which arise separately, and the penial retractor, which arises close to the left buccal retractor.

Reproductive organs (Pl. VIII, fig. 18).—The hermaphrodite gland is compact, and occupies the apex of the spire. The hermaphrodite duct is long, slender, and very little convoluted, but bears towards its posterior end a number of small vesicular outgrowths. The albumen gland is of moderate size. Grains of dark pigment are scattered through the connective tissue which surrounds the hermaphrodite and albumen glands, and these organs are thus easily distinguishable from the more lightly coloured liver which lies

between them. The oviduct, which is separate from the male duct throughout its length, may be divided into three parts—a posterior convoluted portion, narrow near the albumen gland, but becoming broader anteriorly; a median, greatly swollen portion, with translucent glandular walls; and an anterior portion, which is also broad and glandular, but is of an opaque yellow colour and very brittle in alcohol. The receptaculum seminis or spermatheca is oval and about 1 mm. long, with a short duct. The vagina is rather short, and is darkly pigmented.

The vas deferens is slender, and is closely convoluted in the posterior part of its course near the albumen gland. It passes forwards close to the oviduct, occupying a slight groove in the wall of the swollen translucent portion. In front of this, beside the opaque portion of the oviduct, it bears a flattened prostate gland, which is composed of a number of irregular tubules, as shown in the figure. After being embedded in the skin between the female and male openings, the vas deferens emerges again into the body-cavity beside the penis-sac and pursues a sinuous course to the posterior end of the penis, this part of it being very long. The penis itself is narrow, except at the end where the vas deferens enters it, where it is slightly swollen. It is nearly as long as the penis-sac, which, however, is a much broader structure, measuring about $2 \times \cdot 5$ mm. Internally the penis-sac bears two longitudinal folds, as well as numerous smaller transverse or circular folds. The penis bears no flagella, such as occur in the genus *Segmentina*. The penial retractor is inserted where the penis enters the penis-sac.

The spermatozoa (Pl. VIII, fig. 16) have narrow, spirally twisted heads, ·0055 mm. in length, and long slender tails, which have the appearance of being furnished with two extremely fine spiral ridges or striae.

Until more is known about the detailed anatomy of all the species of Planorbinae for which various sectional names have been proposed, I prefer to follow those authors who regard most of them as subgenera of *Planorbis* and *Segmentina* rather than as distinct genera. The apertural dentition of *Planorbula*, however, appears to be merely a passing phase at an early stage of growth, and I think it more logical to retain it in *Planorbis* than in *Segmentina*, while on conchological and, I believe, anatomical grounds, I may be justified in regarding *Hippeutis* as an unsegmented subgenus of *Segmentina*.

Subgenus GYRAULUS Agassiz, 1837.

Planorbis (Gyraulus) costulatus Krs., 1848.

1848. *Planorbis costulatus* Krs., Südafr. Moll., p. 83, pl. 5, fig. 8. D.F.

Hab. L. MARQUES. Makulane; R. Mitembe, not far from Little Lebombo Hills (Junod).

Several specimens in perfect agreement with the ordinary Natalian form.

Subgenus SPIRALINA Hartmann, 1899.

Planorbis (Spiralina) anderssoni Ancey, 1890.

1890. *Planorbis anderssoni* Ancey, Bull. Soc. Mal. Fr. vii, p. 161. D.

Hab. L. MARQUES. Hangwane; Nwambukoto, Rikatla (Junod).

Six examples, quite typical of this species as identified by Ancey from Durban.

Genus SEGMENTINA Fleming, 1818.

Subgenus HIPPEUTIS Agassiz, 1837.

Segmentina (Hippeutis) junodi (Conn.), 1922.

(Plate IV, fig. 30.)

1922. *Hippeutis junodi* Conn., A.M.N.H. x, p. 121. D.

Hab. L. MARQUES. Nwambukoto, Rikatla (type); Hangwane (Junod).

The extreme declivity of the outer lip from suture to periphery seems to distinguish *H. junodi* from other African members of the subgenus.

Cawston has collected some young examples of another species at Beira, but they are too immature for exact identification.

FAMILY ANCYLIDAE.

SUBFAMILY FERRISSIINAE.

Genus FERRISSIA Walker, 1903.

Ferrissia junodi sp. n.

Shell small, conical, rather depressed, irregularly oval, narrowing posteriorly, rather thin, translucent, corneous, brownish black; surface glossy, growth lines regular, rather strong, apex strongly microscopically radially striate, blunt, considerably inclined to the right, situate less than one-fifth of total length from posterior margin. Anterior margin broadly rounded, posterior rather narrowly so; right lateral margin nearly straight, left much curved, both inclined posteriorly towards each other. Anterior slope regular, slightly curved, posterior and right lateral slopes nearly straight and very steep.

Long. 4·1; lat. 2·4; alt. 1·25 mm.

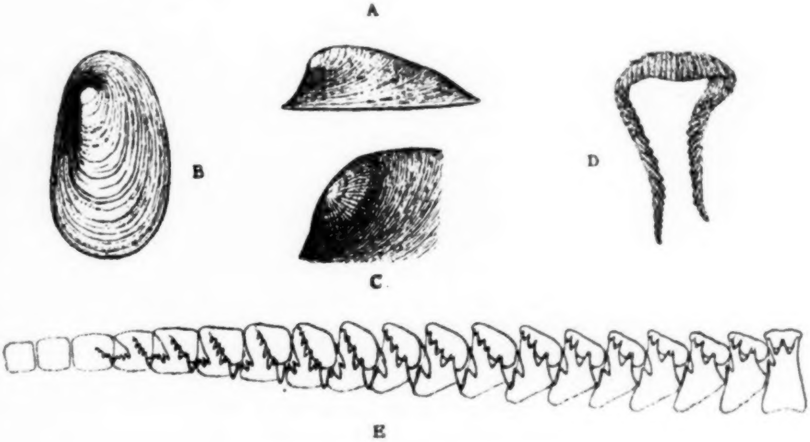
Hab. L. MARQUES. Nwambukoti Pool, Rikatla (Junod).

The animal appears to be sinistral, with a broad pallial lobe on the left side between the mantle and the foot; the soft parts, however, were greatly shrivelled in the only specimen in which they were available for examination.

The jaw (text-fig. 26, D) is brown, and may be said to consist of a median

transverse portion, measuring about ·2 × ·05 mm., and a pair of elongated lateral portions, measuring about ·3 × ·03 mm., but tapering below and having their upper ends directly continuous with the outer ends of the median portion. The entire jaw is divided into numerous narrow plates, of which the inner ends, pointing obliquely downwards, strongly denticulate the edges of the lateral portions of the jaw, in which region the plates are transversely striated.

The radula (text-fig. 26, E) seems to be nearly 1 mm. long when flattened



TEXT-FIG. 26.—*Ferrissia junodi* Conn.

A. Shell viewed from the right side; ×7·5.
B. Shell viewed from above; ×7·5.
C. Apex of shell viewed from the right side; ×28.
D. Jaw; ×80.
E. Half a row of teeth from the radula; ×1200.

out, but is only ·2 mm. in breadth. The central tooth in each row is rather narrow, with two short, equal mesocones, and on each side a vestige of a very minute ectocone. Its basal plate is long, and broadens a little towards the posterior end. The lateral teeth are wider than the central, and their anterior edges slope obliquely forwards and outwards. Each of them bears a well-marked endocone, uniting at its base with the somewhat larger mesocone, on the outer side of which there are either two or three short ectocones. The basal plates of the lateral teeth have their outer sides somewhat elongated in an oblique direction. In the marginal teeth the basal plates become almost square, the endocones become split into three small cusps, and there are usually four narrow ectocones; but the mesocones

remain undivided and larger than the other cusps. The transition from the lateral to the marginal type of tooth is gradual and ill defined. The transverse rows of teeth trend very slightly forwards on each side of the middle line. The radular formula is: $(8+10+1+10+8) \times$ more than 90.

The marginal teeth in this species are of a slightly different type from those shown in Bryant Walker's figures of the radulae of other African Ancylidae,* the cusps being farther from the anterior edges of the teeth and the mesocones larger in proportion to the other cusps. Somewhat similar marginal teeth, however, are possessed by some of the American species of *Ferrissia*, such as *F. parallela* (Hald.).

The lateral teeth are a little more like those found in the genus *Burnupia* than are those of most species of *Ferrissia* that have been examined, although the forms of teeth possessed by these two genera seldom differ very greatly from each other. Walker states that in *Ferrissia*, and in the subfamily Ferrissiinae as a whole, endocones are wanting; † but these statements appear to be erroneous. In *Burnupia*, a genus which is placed in the Ferrissiinae by Walker, he himself states correctly that endocones are present, more or less united with the mesocones in the lateral teeth. In *Ferrissia* the endocones seem to be usually more distinct than in *Burnupia*, being either separate from the mesocones in the lateral, as well as in the marginal teeth, or merely united with them basally, as in the present species.

The nearest recorded approach to this species appears to be a single example from Damar, Transvaal, figured by Walker ‡ as a form of his *F. cawstoni*, from which form it differs chiefly in the curve of the left lateral margin. *F. junodi* differs so widely, however, from typical *cawstoni*, that if it happens to be conspecific with the Damar shell, the latter certainly requires a distinct specific name.

Family POMATIIDAE.

Genus Tropidophora Troschel, 1847.

Subgenus Ligatella von Martens, 1880.

Tropidophora (Ligatella) anceps (Mts.), 1878.

1878. *Cyclostoma anceps* Mts., Monatsb. Ak. Wiss. Berlin, p. 288, pl. 1, fig. 4. D.F.

Hab. L. Marques. Andrada (Vasse).

A large species, described from Taita, Kenya Colony, and fairly common in East Africa.

* "The Ancylidae of South Africa," 1923.

† *Ibid.*, pp. 14, 67.

‡ *Ibid.*, pl. 2, fig. 6.

Tropidophora (*Ligatella*) *calcarea* (Sow.), 1847.

1847. *Cyclostoma calcareum* Sow., Thesaurus Conch. i, p. 118, pl. 26, fig. 113. D.F.

Hab. Mozambique (Gibbons).

L. Marques. Tette (Kirk; Thomson).

A well-known species, easily recognisable on account of its strong spiral costulation.

Tropidophora insularis (?) (Pfr.), 1852.

(Plate VI, figs. 5–9.)

1854. *Cyclostoma insulare* Pfr., Conch. Cab., p. 351, pl. 45, figs. 5, 6. D.F.

Hab. L. Marques. District north of Macequece (Cressy).

I am unable to find any constant points of distinction between the shells of a large series collected by Cressy and what is generally accepted as the typical form of *insularis* from Natal, but it will be seen that the anatomy differs to a certain extent. Fuller knowledge of the genus is necessary before we can determine whether the Macequece race is varietally or specifically distinct.

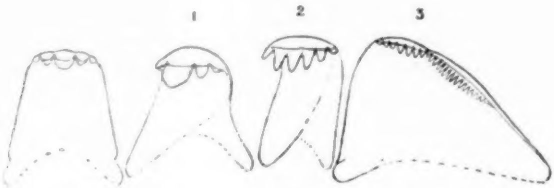
The following are some notes on the anatomy of this form :—

External features of the animal (Pl. VI, figs. 8, 9).—The tentacles are deep yellow, and are very slightly swollen towards their extremities. The conspicuous black eyes are situated on slight prominences at the outer bases of the tentacles. The rest of the animal is of a drab colour, being darkest on the top of the muzzle. This organ is rather long, and is crossed by transverse grooves, except in the centre of its lower surface, where a pair of longitudinal grooves occurs. The sides of the animal are covered by a very fine network of grooves. The foot-sole is cleft longitudinally, and, as the animal moves, the two halves of the foot are used alternately, the end of the muzzle being also applied to the ground at frequent intervals.

Pallial organs, etc. (Pl. VI, fig. 7).—The blood-vessels, which branch over the greater part of the roof of the mantle-cavity, are edged with black pigment, and therefore stand out very prominently, as shown in the figure. Towards the front end, however, they break up into a fine network of veins, and the pigment becomes diffused over the intervening spaces. An osphradium is present at the left side of the mantle-cavity. The kidney is light brown and rounded in outline, although its left side is slightly indented by the pericardium. Posterior to the kidney there is a branched concretionary gland, which was full of opaque white concretions in two of the three specimens examined.

Central nervous system.—The arrangement of the nerve-ganglia in this

species bears a close resemblance to that found in *Pomatias elegans* (Müll.), as described and figured by de Lacaze-Duthiers,* Garnault,† and others. The cerebral ganglia are situated just behind the convoluted salivary glands, and are joined by a commissure which is slightly shorter than the breadth of each ganglion. The buccal ganglia occur farther forwards on the buccal mass, but behind the opening of the oesophagus. The cerebro-buccal connectives and the buccal commissure are very slender. The right pleural ganglion is close to the right cerebral ganglion, but the left is lower down, the left cerebro-pleural connective being about twice as long as the right. The left pallial nerve arises from the left pleural ganglion, but the right pallial nerve arises from the right pleuro-pedal connective close to its union with the right pedal ganglion. Dialyneurous connections



TEXT-FIG. 27.—*Tropidophora* (*Ligatella*) *insularis* (?) (Pfr.), Macequece. Representative teeth from the radula ; ×150.

appear to occur between the pallial nerves on each side and the supra-intestinal and sub-intestinal ganglia, but they are so slender as to be difficult to trace. The rounded pedal ganglia are partly covered by the muscles of the foot. The crossed visceral loop is of considerable length. The abdominal nerve-centre comprises two separate ganglia, the right one of which is the larger and sometimes appears to be double.

Digestive system.—The radula (text-fig. 27) is about 6¾ mm. long, and has 230 transverse rows, of teeth. The central teeth are usually furnished with five short cusps, of which the middle one is the largest. Some of the central teeth, however, have six cusps, one of the small outer cusps being divided into two. The first lateral teeth have five or six cusps, the third from the inner edge being much the largest. The second lateral teeth usually have six or seven rather narrower cusps, and some of them have as many as eight. The marginal teeth are much broader, and may have been formed originally by the union of several narrower teeth similar to those found in the Rhipidoglossa. They may be divided into three portions :

* Arch. Zool. Expér., vol. i, 1872, pl. iii, fig. 8.
† Actes Soc. Lin. Bordeaux, 1887, vol. xli, pl. i.

an inner division with six to nine small cusps or denticles, a middle division with about eighteen or twenty narrow denticles, like the teeth of a comb, and an outer more delicate portion without any denticles. This outer portion is not developed at the hind end of the radula, the teeth in the last thirty-five being without it. The transverse rows are ·03 mm. apart; and as the bases of the teeth are about five times this length, the successive rows overlap to a great extent. In about seventy of the rows towards the hind end of the radula the thicker parts of the teeth are coloured brown.

In its radula this species bears a close resemblance to those of the other South African species of the subgenus *Ligatella*, which seem to have very similar radulae, differing from one another and from the present form only in small details. The radula of *Pomatias elegans* is of a slightly different type, but that of the Mediterranean species, *P. melitensis*, differs but little from those of this African group.

The radula-sac projects a considerable distance from the hind end of the buccal mass, and is bent upwards and forwards (Pl. VI, fig. 5). The salivary glands are long and narrow; but they are much convoluted and twisted, so that they do not extend far back. The oesophagus is narrow except near the salivary glands, where it is slightly swollen. It opens into the stomach in about the middle of this organ, which is long and curved. The posterior part of the stomach, which ends blindly, has a furrow running along its convex surface. The intestine arises from the opposite end, and is folded upon itself twice or thrice before passing forward to the rectum, as shown in the figure. The anus is situated on the right side of the mantle-cavity towards the front end.

Reproductive organs.—Of the three specimens examined one was a male and two were females. The male genital ducts are shown in fig. 6. The upper part of the sperm-duct is convoluted and somewhat swollen. Further forwards it passes into the rather large, oval, prostatic gland, the posterior part of which is pale grey, and the anterior white. The external layer of the gland is formed of small papillae, those on the anterior white portion being best developed. In front of the prostatic gland the vas deferens is very slender. It passes into the large muscular penis, which lies bent upon itself in the mantle-cavity. The penis broadens towards the middle and then narrows considerably, to end in a long, slender point. A number of shallow transverse grooves cross the anterior part on one side.

Unfortunately both the female specimens were slightly immature as regards their reproductive organs as well as in their shells. Nevertheless the full-grown shell of the male was slightly the smallest of the three specimens. This is interesting, as Boycott * has recently shown that in

* Proc. Mal. Soc., vol. xii, 1917, pp. 127–132.

Pomatias elegans the females are on an average decidedly larger than the males. It is probable therefore that the Macequece *Tropidophora* agrees with the European species in this character, as it undoubtedly does in the more important features of its anatomy.

The animals of *Tropidophora* (*Ligatella*) *insularis* (Pfr.), from various localities in Natal, are of a paler colour than those of the form just described, the head and adjacent parts being less darkly pigmented, the tentacles not such a deep yellow, and the pulmonary veins edged with light grey instead of black. Moreover, the anterior edge of the kidney seems to curve forwards a little more above the heart in these specimens of *T. insularis* from Natal; the radula is relatively slightly smaller, and was not bent forwards in the animals dissected; and the denticles on the middle division of the marginal teeth are rather broader and less numerous, their average number being about eleven or twelve.

Tropidophora (*Ligatella*) *kraussiana* (Pfr.), 1852.

1854. *Cyclostoma kraussianum* Pfr., Conch. Cab., p. 334, pl. 43, figs. 17–18. D.F.

Hab. L. Marques. Inhambane (Gibbons).

A record of very doubtful authenticity.

Tropidophora (*Ligatella*) *letourneuxi* (Ancey), 1887.

1887. *Rochebrunia letourneuxi* Ancey, Bgt., Bull. Soc. Mal. Fr. iv, p. 270. D.

Hab. Mozambique coast (Stuhlmann).

Tropidophora (*Ligatella*) *ligata* (Müller), 1774.

1786. *Turbo ligatus* Müll., Chem., Conch. Cab. ix, 2, p. 60, pl. 123, figs. 1071–1072; 3–4. D.F.

Hab. Mozambique coast (Stuhlmann).

L. Marques. Tette (Peters); Rikatla (Junod); Delagoa Bay (Barnard); Wanetsi R., Magude District (Bell Marley); Zangwe Basin (Cressy).

Tropidophora (*Ligatella*) *nyasana* (Smith), 1899.

1899. *Pomatias nyasanus* Smith, P.Z.S., p. 591, pl. 35, fig. 5. D.F.

Hab. Mozambique. Frontier 7 miles south of Mt. Dedza, Nyasaland (Mrs. Connolly).

Tropidophora (*Ligatella*) *zanguebarica* (Petit), 1850.

1850. *Cyclostoma zanguebaricum* Petit., J. de C. i, p. 53, pl. 3, fig. 5. D.F.

Hab. MOZAMBIQUE (Gibbons ; cum mut. *albina*, Frey).

FAMILY AMPULLARIIDAE.

Genus AMPULLARIA Lamarck, 1799.

Ampullaria largillierti Phil., 1848.

1848. *Ampullaria largillierti* Phil., Zeitschr. f. Malak. v, p. 192. D.

1857. „ *wernei* Phil., var., Mts., Mal. Blätt. iv, p. 187. N.

1879. „ *largillierti* Phil., Mts., Monatsb. Ak. Wiss. Berlin, p. 733. L.

Hab. MOZAMBIQUE. Querimba I. (Peters).

I have not seen Peters' shells, which von Martens first considered to be a variety of the widely diffused African *wernei* and subsequently attributed to *largillierti*, a Madagascan species.

Genus LANISTES de Montfort, 1810.

Lanistes ovum Ptrs., 1845.

1851, 52. *Ampullaria ovum* Ptrs., Phil., Conch. Cab., p. 22, pl. 6, fig. 2. D.F.

1866. *Lanistes ellipticus* Mts., Novit. Conch. ii, p. 294, pl. 70, figs. 9–10. D.F.

1866. *Lanistes ovum*, var. *elatior* Mts., *ibid.*, p. 291, pl. 70, figs. 7, 8. D.F.

„ „ *olivaceus*, var. *ambiguus* Mts., *ibid.*, p. 292, pl. 71, figs. 3–4. D.F.

1877. *Lanistes affinis* Smith, P.Z.S., p. 716, pl. 74, fig. 7. D.F.

„ „ *solidus* Smith, P.Z.S., p. 716, pl. 74, figs. 10–11. D.F.

1886. „ *zambesianus* Furtado, J. de C. xxxiv, p. 148, pl. 7, fig. 1. D.F.

1886. *Lanistes ellipticus*, var. *trapeziformis* Furt., *ibid.*, p. 150. D.

Hab. MOZAMBIQUE coast (Frey) ; Mopera, R. Quaqua ; Quilimane (Stuhlmann).

L. MARQUES. Tette (type, Peters ; Ivens and Capello) ; Itschongove, Delagoa Bay (Schenck) ; L. Pavi ; L. Mhandlen ; Rikatla (Junod) ; Wanetsi R., Magude Dist. (Bell Marley) ; Beira (Cawston ; Connolly) ; Mtisherra R. Valley (Cressy).

In the case of this and the next species I have followed Sowerby's synonymy,* with which I fully agree.

* Proc. Mal. Soc. xii, 1916, pp. 67–68.

Lanistes olivaceus (Sow.), 1834.

1834. *Paludina olivacea* Sow., Gen. Shells, part 41, pl. 183, fig. 3. D.F.

1839. *Ampullaria purpurea* Jonas, Arch. f. Naturg. v, 1, p. 342, pl. 10, fig. 1. D.F.

1839. *Bulimus tristis* Jay, Cat. Shells, p. 121, pl. 7, fig. 1. N.F.

1840. *Meladomus bulimoides* Swains., Treatise Malac., p. 340. D.

1866. *Lanistes olivaceus* Sow., var. *procerus* Mts., Novit. Conch. ii, p. 292, pl. 71, figs. 1–2. D.F.

Hab. MOZAMBIQUE. Near Cabaceira (Kirk).

L. MARQUES. Gorongozo Dist. (Wells-Cole).

The shell of this species is usually considerably more elongate than that of *L. ovum*, and easily distinguishable.

FAMILY VIVIPARIDAE.

Genus VIVIPARA de Montfort, 1810.

Vivipara capillata Frnfd., 1865.

1865. *Vivipara capillata* Frnfd., Verh. Zool. Ges. Wien. xv, p. 533, pl. 22. D.F.

Hab. L. MARQUES. Rikatla; L. Mhandlen; L. Pavi (Junod).

The single example from L. Pavi is unusually slender, measuring 23·8×16 mm., apert. 11·2×8·8 mm., and thus resembles some of the Nilotic forms of *V. unicolor* (Oliv.) rather than *capillata*, but the material is insufficient to admit of further surmise.

Genus CLEOPATRA Troschel, 1857.

Cleopatra ferruginea (Lea), 1850.

1850. *Melania ferruginea* Lea, P.Z.S., p. 182. D.

1851. ,, *zanguebarensis* Petit, J. de C. ii, p. 263, pl. 7, fig. 1. D.F.

,, ,, *amaena* Morel., *ibid.*, p. 192, pl. 5, fig. 9. D.F.

1860. ,, *ferruginea* Lea, Rve., Conch. Icon., pl. 21, fig. 147. D.F.

1878. *Paludomus africana* Mts., Monatsb. Ak. Wiss. Berlin, p. 297, pl. 2, figs. 11–13. D.F.

Hab. MOZAMBIQUE. Mopera, R. Quaqua, near Quilimane (Stuhlmann).

L. MARQUES. L. Mhandlen; L. Schwabe (Junod).

The limits of variation and distribution of this species are not satisfactorily defined, as many specimens attributed to it in collections are in such poor condition that their exact identification can only be a matter

of conjecture. Into this category fall the 4 shells collected by Junod; they are all much worn, showing the broad brown band which is characteristic of *C. ferruginea*, but with rather more convex whorls than are usually seen in fresh examples of that species.

Cleopatra morrelli Preston, 1905.

1905. *Cleopatra morrelli* Prest., Proc. Mal. Soc., p. 300. D.F.

Hab. L. Marques. Wanetsi R., Magude District (Bell Marley).

Only known previously from the Victoria Falls.

Cleopatra bulimoides (Oliv.), 1804.

1804. *Cyclostoma bulimoides* Oliv., Voy. Emp. Ott. iii, p. 68, pl. 31, fig. 6.

Hab. Mozambique. R. Rovuma (Kirk, fide Dohrn).

I cannot trace Kirk's specimen in the British Museum, where it might be expected to be found. I consider it almost certain, however, that it must have been an immature example of *ferruginea*, rather than Olivier's Egyptian species.

Family TIARIDAE.

Genus Tiara Bolten, 1798.

Tiara vouamica Bgt., 1889.

1879. *Melania crenularis* Desh., Mts., Monatsb. Ak. Wiss. Berlin, p. 733. L.

1889. *Tiara vouamica* Bgt. (=*crenularis* Mts., non Desh.) Bgt., Moll. Afr. équat., p. 183. D.

1897. *Melania coacta* Meusch., Mts., D.-O.-A., p. 197, pl. 6, fig. 36. D.F.

1915. *Tiara coacta* Mts., Conn., Ann. S. Afr. Mus. xiii, p. 100. N.

Hab. Mozambique (Peters).

L. Marques. Estuary of Nkomati R. (Junod).

In 1915 I proved that the name *coacta*, as originally applied by Meuschen, was void, and that the *Melania coacta* quoted by von Martens should bear the latter's name as author. However, on p. 183 of D.-O.-A. von Martens places *vouamica* Bgt. in the synonymy of *coacta* Meusch., while on p. 198 he admits that *coacta* Meusch., not *crenularis* Desh., is the correct identification of the shells collected by Peters in Mozambique. Under these circumstances, *Tiara vouamica* Bgt. (1889) has precedence of *T. coacta* Mts. (1897), which must be relegated to synonymy.

Genus MELANOIDES Olivier, 1807.

Melanoides tuberculatus (Müller), 1774.

1786. *Nerita tuberculata* Müll., Chem., Conch. Cab. ix, 2, p. 189, pl. 136, figs. 1261–1262. D.F.

1860. *Melania inhambanica* Mts., Mal. Blätt. vi, p. 216, pl. 2, fig. 10. D.F.

Hab. MOZAMBIQUE. Mopera, R. Quaqua (Stuhlmann).

L. MARQUES. Tette; Inhambane (Peters); L. Pavi; Lebombo Marsh, Rikatla (Junod); Zangwe Basin (Cressy).

M. inhambanica Mts., which has long been acknowledged as identical with *tuberculatus*, was originally differentiated on account of its greater size, 32×11 mm., while in D.-O.-A., 1897, von Martens mentions examples from the Tanganyika Territory as large as 37×13 mm. These are smaller than the biggest of Cressy's bleached series from the Zangwe Basin, one of which, lacking the apex, measures 41·0×16·1 mm., while a smaller unbroken example is 39·5×14·0 mm.

FAMILY ASSIMINEIDAE.

Genus ASSIMINEA Leach, 1828.

Assiminea bifasciata Nevill, 1880.

1880. *Assiminia bifasciata* Nev., Journ. As. Soc. Bengal, xlix, 2, p. 162. D.

Hab. L. MARQUES. Estuary of Nkomati River (Junod).

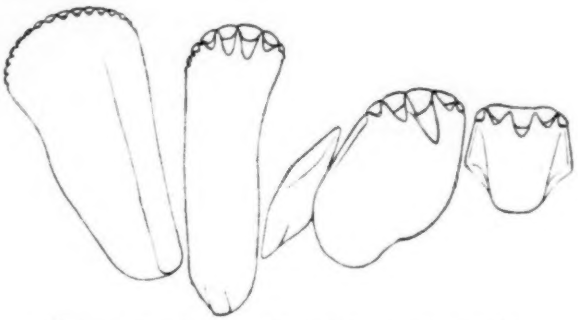
The shells agree in all respects with the typical form from Natal.

The radula * (text-fig. 28) has 58 rows of teeth, and is about 1·35 mm. in length. Each transverse row contains nine teeth. The central tooth has five cusps, borne on a broad but rather short base. The first lateral tooth on each side is larger than the central, with a somewhat oval basal plate; it also has five cusps, the middle one being rather long. Next there is a small, rather narrow tooth, without any distinct cusps, similar to that which occurs in the more typical species of *Assiminea*. The third tooth has about seven cusps, and a long, rather narrow basal plate. In the fourth or marginal tooth the base is also long, but it is somewhat broader, and bears fourteen or fifteen small cusps or denticles. The transverse rows are ·0225 mm. apart, so that while the long bases of the outer teeth overlap one another to a considerable extent, those of the central teeth hardly do so at all.

Although differing from them in detail, the radula of this species is of

* Described from a radula from Isipingo, Natal, mounted by the late Prof. Gwatkin, who received the animal from Mr. H. C. Burnup of Pietermaritzburg.

the same general type as in other specimens of *Assiminea* from Natal identified as *A. sinica* Nevill and *A. ovata* (Krs.). These species all differ from the British form, *A. grayana* Leach, as well as from the Indian species



TEXT-FIG. 28.—*Assiminea bifasciata* Nev., Isipingo, Natal. Half of a transverse row of teeth from the radula ; ×600.

figured by Annandale and Prashad,* and at least some of the Chinese forms,† in having no basal cusps or denticulations on the sides of their central teeth.

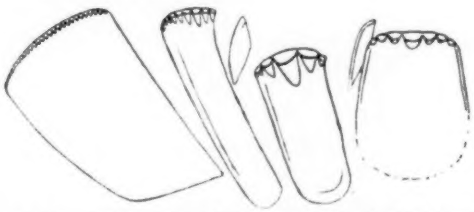
Assiminea leptodonta Conn., 1922.

(Plate IV, fig. 31.)

1922. *Assiminia leptodonta* Conn., A.M.N.H. x, p. 122. D.

Hab. L. MARQUES. Estuary of Nkomati River (Junod).

The radula (text-fig. 29) measures about ·95 mm. in length, and contains 75 rows of teeth in one specimen and 71 in another. There seem



TEXT-FIG. 29.—*Assiminea leptodonta* Conn., Lebombo Marsh, Rikatla. Half of a transverse row of teeth from the radula ; ×600.

to be eleven teeth in each transverse row, which is more than we usually

* Rec. Ind. Mus., vol. xvi, 1919, p. 249, text-fig. 4.

† Heude : Mem. Hist. Nat. de l'Empire Chinois, vol. i, Moll. Terr., 1882, pl. xxi, figs. 4*c*, 5*c*, 6*c*.

find in the Taenioglossa, but four of the teeth are much smaller than the others. The central tooth has seven short cusps, of which the middle one is the broadest; its basal plate is large but very thin. On each side of the central tooth, but quite separate from it, there is a small narrow tooth, having a curved, thickened edge without any distinct denticulations. Next there is a much bigger tooth, with a long basal plate slightly thickened at the posterior edge, and five cusps, of which the middle one is rather large. On the outer side of this there is another small, somewhat diamond-shaped tooth, without any distinct cusps. The fourth tooth on each side has a very long, rather narrow basal plate, and about nine pointed cusps. Lastly, the marginal tooth has a long and broad, but thin, basal plate, and a row of about thirty minute cusps or denticles. The transverse rows of teeth are only ·0115 mm. apart, and the teeth of one row are therefore very largely overlapped by those of the row behind.

The radula of this species agrees with those of *A. bifasciata* Nev., *A. ovata* (Krs.), etc., in having no basal denticulations on the sides of the central teeth. Nevertheless it differs from the radulae of these species and of the more typical members of the genus in several important respects, such as the presence of small additional teeth on each side of the central tooth, the relatively longer basal plates and smaller and more numerous cusps of most of the teeth, and the much greater extent to which the transverse rows of teeth overlap one another. Indeed, even under the low power of the microscope, the radula of this species has such a different appearance from those of most species of *Assiminea* that it would not be surprising if, when the rest of its anatomy has been studied, this form should prove to belong to a distinct, though probably allied, genus.

Family TRUNCATELLIDAE.

Genus Truncatella Risso, 1826.

Truncatella teres Pfr., 1856.

1856. *Truncatella teres* Pfr., P.Z.S., p. 336. D.
Hab. Mozambique. Querimba I. (Peters).

Family NERITIDAE.

Genus Theodoxus de Montfort, 1810.

Theodoxus knorri (Récl.), 1841.

1849. *Neritina knorri* Recl., Sow., Thesaurus Conch. ii, p. 511, pl. 111, fig. 78; pl. 113, fig. 150. D.F.
Hab. L. Marques. Inhambane (Peters).

Theodoxus natalensis (Rve.), 1855.

1855. *Neritina natalensis* Rve., Conch. Icon., pl. 16, fig. 75. D.F.

Hab. MOZAMBIQUE. Quilimane (Peters; Stuhlmann).

L. MARQUES. Inhambane; Tette (Peters); Delagoa Bay; Estuary of Nkomati R., Rikatla (Junod).

LAMELLIBRANCHIA.

FAMILY UNIONIDAE.

Genus INDONAIA Prashad, 1918.

Indonaia mossambicensis (Ptrs.), 1860.

Unio mossambicensis Ptrs., Mts., Mal. Blätt. vi, p. 218, pl. 3, figs. 3–5. D.F.

Hab. L. MARQUES. Tette (Peters).

I am indebted to Dr. F. Haas for the correct generic classification of this little known species.

FAMILY MUTELIDAE.

Genus SPATHA Lea, 1838.

Spatha petersi Mts., 1860.

1860. *Spatha petersi* Mts., Mal. Blätt. vi, p. 218, pl. 3, figs. 1–2. D.F.

Hab. L. MARQUES. Tette (Peters); Itschongove (Schenck); Nkomati River, Rikatla (Junod).

Spatha wahlbergi (Krs.), 1848.

1848. *Iridina wahlbergi* Krs., Südafr. Moll., p. 19, pl. 2, fig. 1. D.F.

Hab. L. MARQUES. Tette (Peters); L. Pavi, Inhambane (Junod).

Junod's shells represent rather an obese form, the measurements being:

Long. 87·0;	alt. 41·5;	diam. 29·5;	umbones from anterior border	23·7 mm.
,, 55·5;	,, 27·0;	,, 16·5;	,, ,, ,, ,,	16·0 mm.

var. *dorsalis* Mts., 1897.

1897. *Spatha wahlbergi* Krs., var. *dorsalis*, Mts., D.-O.-Afr. iv, p. 247. D.

Hab. L. MARQUES. Tette; Sena (Peters).

Genus MUTELINA Bourguignat, 1885.

Mutelina rostrata (Rang), 1835.

1835. *Iridina rostrata* Rang, Nouv. Ann. Mus. Paris, p. 316. D.

1836. *Iridina coelestis* Lea, Syn. Naiades, p. 57. D.

Hab. L. MARQUES. Tette (Peters).

This species was inadvertently omitted from my Reference List in 1913.

Family CYRENIDAE.

Genus Corbicula von Mühlfeld, 1811.

Corbicula africana (Krs.), 1848.

1846. *Cyrena radiata* Parr., Phil., Abb. u. Beschr. ii, p. 78, pl. 11, 4, fig. 8. D.F.

1848. *Cyrena africana*, var. *olivacea* Krs. (=*gauritziana* Krs. in litt. and *radiata* Parr.) Krs., Südafr. Moll., p. 8, pl. 1, fig. 8. D.F.

Hab. L. Marques. Tette (Peters); Itschongove (Schenck); R. Zambesi (*radiata*, Brancksik); Gorongozo District (Wells Cole); Zangwe Basin (Cressy).

The name *radiata* cannot be retained for this species, as it was first described as a *Cyrena*, and is therefore preoccupied by *Cyrena radiata*, Hanley (P.Z.S. 1844, p. 159). However, a new name is unnecessary, since Krauss bestowed on it in 1848 that of *C. africana* var. *olivacea*. At the same time, he stated that this variety was the typical form of the species, so that the varietal name is not required and *africana* can stand alone. The beautiful little shells with radiate umbones often occur in company with those of duller hue, and appear to be quite inseparable from them except as a colour variety.

Corbicula astartina (Mts.), 1860.

1860. *Cyrena astartina* Mts., Mal. Blätt. vi, p. 219, pl. 3, figs. 6–7. D.F.

Hab. L. Marques. Tette (Peters).

Easily distinguishable from any of the *africana* group by its more elongate form.

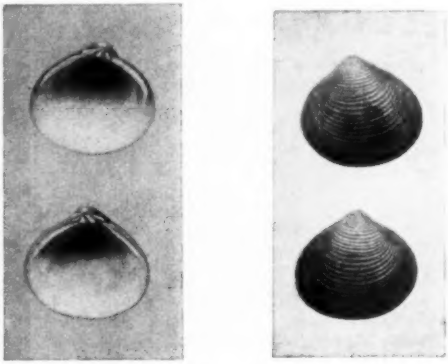
Corbicula kirki Prime, 1864.

1864. *Corbicula kirkii* Prime, Ann Lyc. Nat. Hist. N.Y. viii, pp. 66, 67, fig. 12. D.F.

Hab. Mozambique (Kirk).

In most kindly forwarding me the beautiful photograph, from which the subjoined text-figure has been reproduced, of the type of this species in the United States National Museum, Dr Paul Bartsch remarks: "The type is pale horn coloured on the outside, with the umbones flushed with purple; the interior is very pale purplish, deepening toward the umbones. Another specimen . . . is of much darker colour; in fact, the interior is dark purple."

Prime's original note was "Compared with *Corb. radiata*, this species is less globose, not so inflated, the beaks are not so tumid, the striae are closer, and the colour of the epidermis is different."



TEXT-FIG. 30.—*Corbicula kirki* Prime. Type in U.S. National Museum; ×1.

ALPHABETICAL INDEX OF SPECIES IN ORDER OF GENERA.

Synonyms, and names of species extraneous to P.E.A., are printed in *italics*. The letters L and M after each species denote whether recorded from Lorenzo Marques or Mozambique respectively.

EXPLANATION OF PLATE IV.

Note.—The small outlines given with enlarged figures merely represent the actual size of the shells; they are not to be accepted as accurate in detail.

FIG.
1. *Gonaxis cressyi* Conn. Type. Mtisherra R. Valley.
2. ,, (*Eustreptaxis*) *vengoensis* Conn. Type. Macequece District.
3. *Gulella enneodon* Conn. Type. Macequece District.
4. ,, *laevigata* (?) (Dhrn.). Maforga Siding.
5. ,, *praelonga* Conn. Type. Mount Vengo.
6. ,, *tristãoensis* ,, ,, Macequece District.
7. ,, *nepia* ,, ,, ,, ,,
8. *Sitala diaphana* ,, ,, ,, ,,
9. *Trachycystis ambigua* Conn. Type. Macequece District.
10. ,, *sericea* ,, ,, ,, ,,
11. ,, *cressyi* ,, ,, ,, ,,
12. ,, *fossula* ,, ,, Mt. Vengo.
13. ,, *mcdowelli* ,, ,, Maforga Siding.
14. ,, *soror* ,, ,, Mt. Vengo.
15. ,, *pura* ,, ,, ,, ,,
16. ,, *vengoensis* ,, ,, ,, ,,
17. *Punctum pallidum* ,, ,, ,, ,,
18. *Conulinus junodi* ,, ,, Lebombo Mountains.
19. ,, *sordidulus* Mts. Wanetsi River.
20. ,, *tumidus* (Gibbons) Type. Zanzibar.
21. *Rhachis jejuna* (M. and P.). Lebombo Mountains.
22. ,, *punctata* (Ant.) (Type of *férussaci* Dkr.). Loanda.
23. *Nesopupa vengoensis* Conn. Type. Mt. Vengo.
24. ,, *bandulana* ,, ,, Bandula Siding.
25. *Opeas praecox* ,, ,, Zangwe R. Basin.
26. ,, *vengoense* ,, ,, Mt. Vengo.
27. ,, *cressyi* ,, ,, Macequece District.
28. *Pseudoglessula cressyi* ,, ,, ,, ,,
29. *Auriculastra acuta* ,, ,, Rikatla.
30. *Hippeutis junodi* ,, ,, ,,
31. *Assiminea leptodonta* ,, ,, ,,

EXPLANATION OF PLATE V.

Gonaxis (*Eustreptaxis*) *elongatus* (Fulton) *juv.*, Macequece.

1. Anterior view of head. The upper tentacles are retracted, and the front of the buccal mass is slightly protruded.
2. Retractor muscles of the radula, seen from the right side; ×5½. The dotted lines show the outline of the concealed radula-sac and front portion of its terminal retractor.
3. Anterior portion of alimentary canal with odontophore and free retractor muscles, seen from the left side; ×5½.

Helicarion (Gymnarion) nyasanus Smith, Macequece.

FIG.

4. Posterior part of the animal, seen from the right side after the removal of the shell; ×3.
5. Dorsal view of left pallial lobes.
6. Dorsal view of posterior portion of foot.
7. Dorsal view of reproductive system (slightly immature), free retractor muscles, anterior portion of digestive system, and cerebral ganglia; ×5. The penis is displaced towards the right, and the crop, with the salivary glands, towards the left.
8. Jaw; ×12.

Subuliniscus chiradzuluensis (Smith), Macequece.

9. Embryo from uterus, with the mantle-margin and the foot projecting from the aperture of the shell; ×9.
10. External view of kidney, ureter, and heart of embryo; ×12.
11. Jaw (of adult); ×24.
12. Anterior end of spermatozoon; ×1200.
13. Dorsal view of hind end of foot.
14. Dorsal view of alimentary canal with salivary glands; ×5.
15. Dorsal view of free retractor muscles and reproductive system; ×5.
16. Central nervous system.

EXPLANATION OF PLATE VI.

Pseudoglessula (Pseudocerastus) boivini (Morelet), Kosi Bay, Zululand.

1. Pallial organs seen from within, showing the roof of the lung, with the mantle-edge and left body-lobes above, the heart and kidney below, and the rectum on the left side; ×3.
2. Transverse section through pedal gland slightly in front of the middle of its length; ×11.
3. Jaw; ×13.
4. Free retractor muscles, and genital ducts (slightly immature), with buccal mass, oesophagus, salivary glands, and cerebral ganglia; ×5.

Tropidophora (Ligatella) insularis (?) (Pfr.), Macequece.

5. Dorsal view of alimentary canal, showing the buccal mass with the recurved radula-sac and convoluted salivary glands above, and the stomach below; ×4½.
6. Male genital duct, showing the large penis above, and the prostatic gland in the middle; ×4½.
7. External view of pallial organs, showing the pulmonary veins, with the heart and kidney below; ×5.
8. Living animal seen from the right side; ×3.
9. Living animal seen from below; ×3.

EXPLANATION OF PLATE VII.

Pseudoglessula (Pseudocerastus) cressyi Conn., Macequece.

1. Representative teeth from the radula; ×400.
2. Dorsal view of hind end of foot.
3. Nerve-ring; ×12.

FIG.

4. Anterior end of spermatozoon ; ×1000.
5. Reproductive organs ; ×6.
6. Retracted animal without its shell ; ×5.
7. Living animal ; ×2½.

EXPLANATION OF PLATE VIII.

Ledoulxia mozambicensis (Pfeiffer), Lebombo Mountains.

1. Retracted animal without its shell, showing distribution of pigment on mantle, etc. ; ×4.
2. Hind end of foot of an abnormal specimen, seen from above, showing the forked caudal lobe ; ×4.
3. Reproductive organs ; ×5.
4. Central nervous system ; ×10.

Conulinus junodi (Conn.), Lebombo Mountains.

5. Anterior part of immature male genital organs, showing the penis in the centre, the epiphallus on the right, and the penial appendix on the left, with the penial retractor and flagellum below ; ×16.
6. Central nervous system ; ×12.
7. Animal without its shell, showing part of foot, kidney, stomach, liver, etc. ; ×4.

Isidora (Physopsis) globosa (Morelet), Lorenzo Marques.

8. Pulmonary orifice, with the folded branchial lobe, anus, etc., on the right of it ; ×5.
9. Central nervous system; ×14.
10. Anterior end of spermatozoon ; ×1200.
11. Posterior end of penis with its sheath split open, showing the junction of the vas deferens with the penis ; ×11.
12. Alimentary canal and salivary glands, seen from above ; ×6.
13. Animal without its shell, seen from the left side ; ×3.
14. Reproductive organs ; ×5.
15. Posterior end of penis, showing penis-papilla—this specimen exhibiting a different condition from that seen in fig. 11 ; ×12.

Planorbis (Planorbula) pfeifferi (Krauss), Lorenzo Marques.

16. Anterior end of spermatozoon ; ×1200.
17. Lobes beneath the pulmonary orifice, seen from above ; ×8.
18. Reproductive organs ; ×8.
19. Buccal mass, salivary glands, œsophagus, stomach, caecum, and first loop of intestine ; ×6.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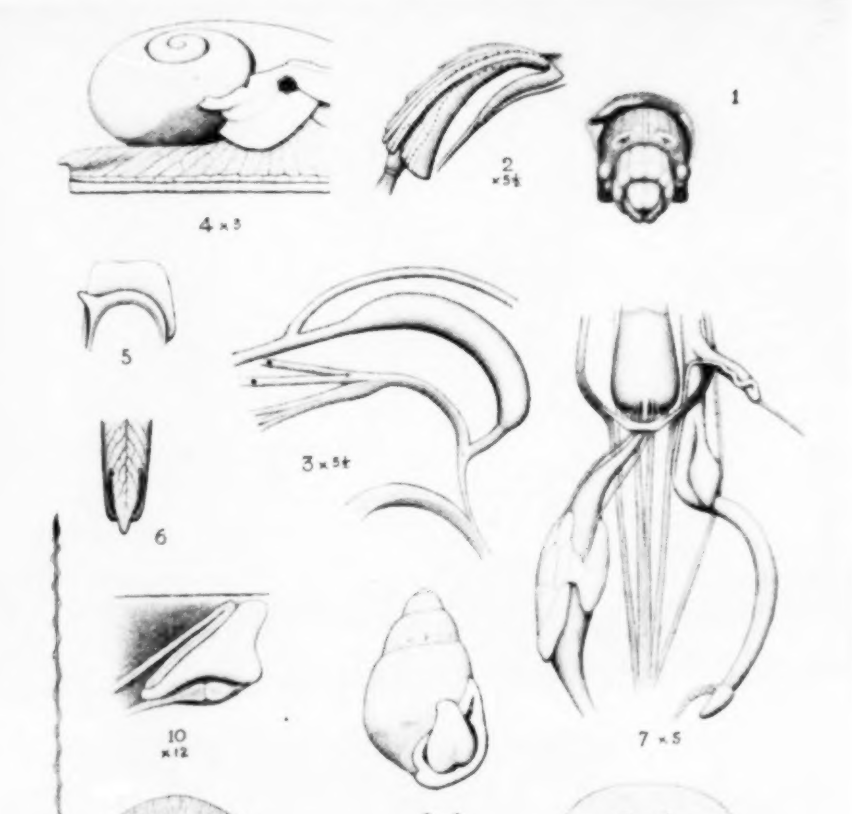
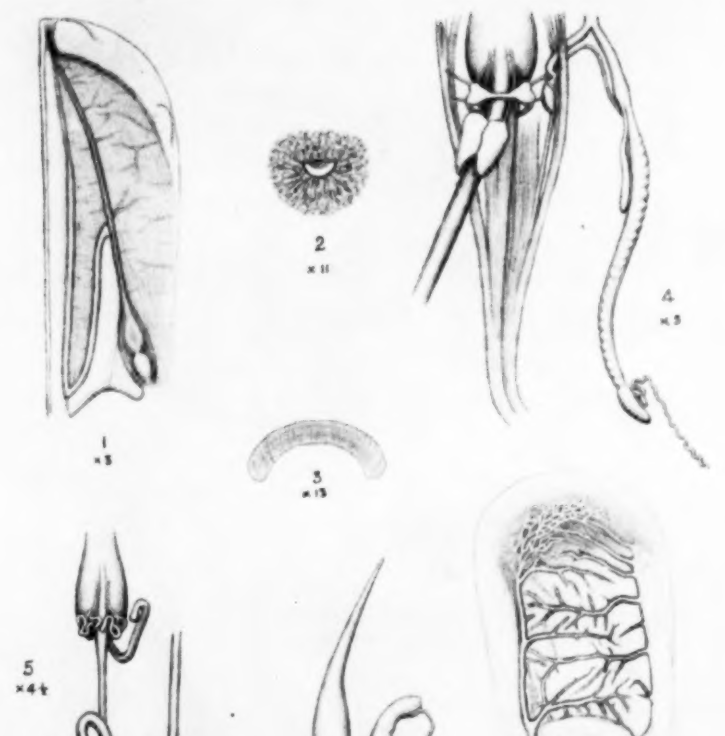
K. Wing, del.



H. Watson, del.



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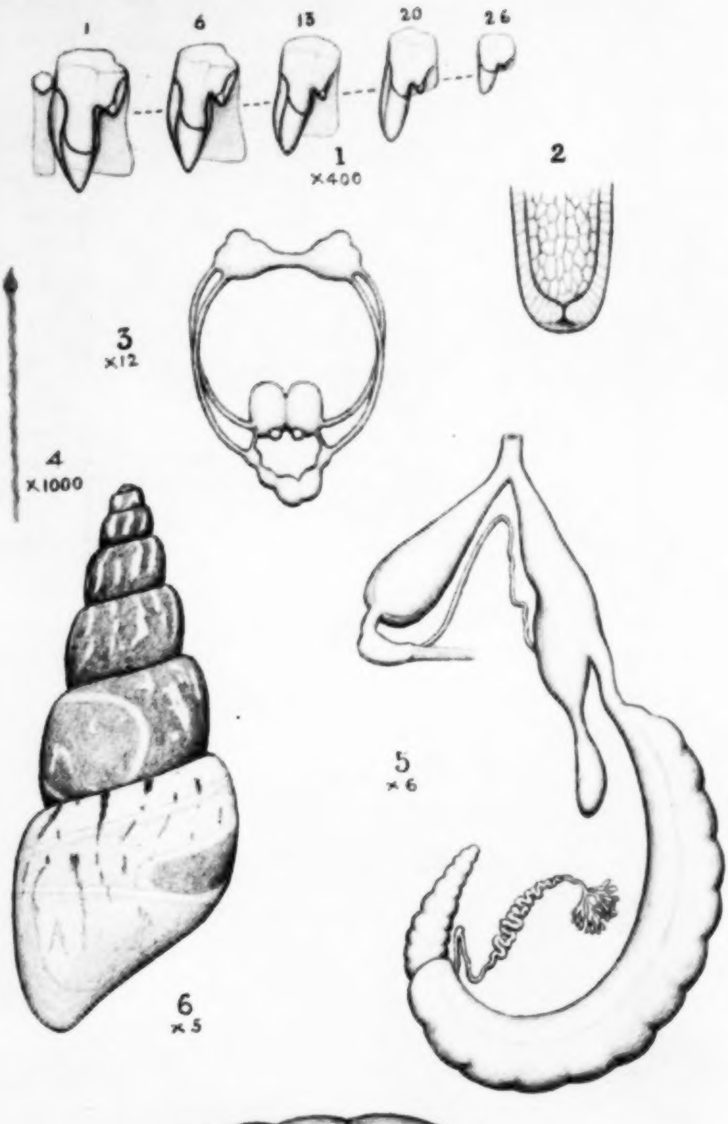

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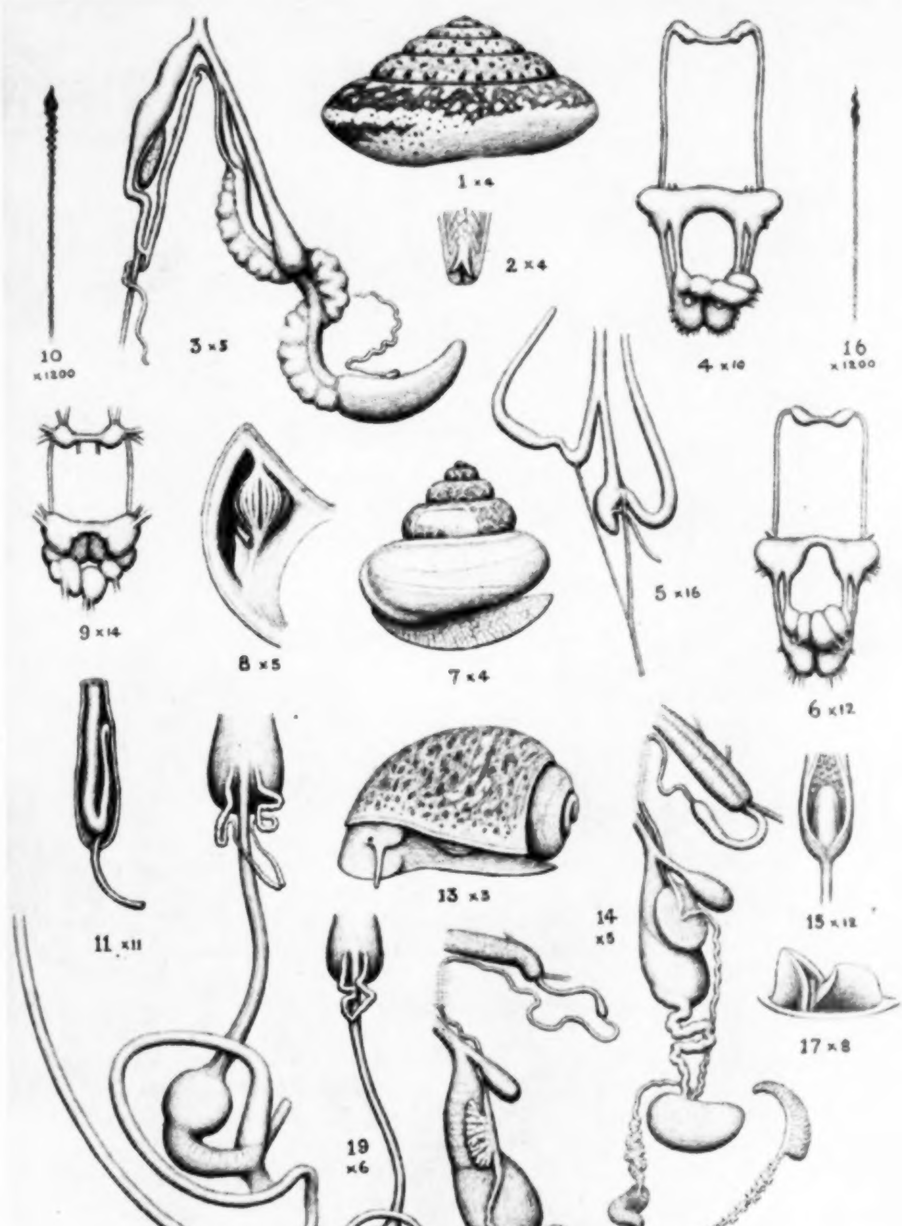
1 ×4
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18 ×8
19 ×6

H. Watson, del.

ON VARIATION AND HEREDITY IN THE BRUCHIDAE.

By S. H. Skaife, M.A., M.Sc., Ph.D.

(With Plates IX–XI.)

Material and Methods.

The Bruchidae are a small family of beetles the majority of which spend their larval stages in the seeds of leguminous plants. The family is well represented in South Africa; in addition to a number of indigenous species that breed in the seeds of *Acacia* spp. and other native legumes, there are five species of economic importance that have been introduced from overseas. The present paper deals with three of the introduced species: the common bean weevil, *Acanthoscelides obtectus*, Say; the common cowpea weevil, *Callosobruchus chinensis*, Lin.; and the four-spotted weevil, *Bruchus quadrimaculatus*, Fabr. It is surprising that these bruchids have not hitherto been taken up by students of variation and heredity, for their habits make them excellent subjects for experimental breeding. Certain species, including the three mentioned above, will breed freely in confined spaces, and require the least possible care and attention—a very important consideration when one has to deal with large numbers of cultures.

A. obtectus infests beans and is very common and widely spread in South Africa. The female bites a narrow slit in the ventral suture of a ripe pod, inserts her ovipositor in the slit, and drops her eggs loosely inside the pod. The eggs hatch in ten days or so, and the larvae burrow into the beans, the entrance holes being so minute as to be almost invisible. *C. chinensis* and *B. quadrimaculatus* both attack cowpeas, *Vigna catjang*; the former is common and widely distributed, but the latter is comparatively scarce and seems to limit its attentions to stored cowpeas. The female of the common cowpea weevil deposits her eggs on the exterior of the ripe, dry pods and the young larvae burrow through the hulls of the pods and enter the seeds inside. When infested beans or cowpeas are harvested, the adult weevils emerge in a few weeks and are capable of breeding freely in the stored seeds. The number of individuals of these species that can come to maturity in a single seed is limited only by the amount of food material contained in that

seed. In the storeroom the bean weevil drops her eggs loosely among the beans, but the two species that attack cowpeas glue their eggs securely to the exterior of the seeds.

When fully grown the larvae pupate inside the cells they have eaten out for themselves in the seeds. These cells are formed just beneath the surface of the seeds, so that the adults are cut off from the open air only by the thin circular cap, consisting of the integument of the seed, that covers the cell. The adults have only to bite through the integument and push off the cap in order to emerge from the cells. The larva pupates with its alimentary canal distended with food, and this food is carried over, in a partially digested state, to the adult stage. Consequently the adults feed sparingly, although they have fully formed and functional mouth-parts, and the females are capable of laying a full complement of eggs without partaking of any solid food at all. Only one species that feeds at all freely in the adult state, *B. pisorum*, Lin., is known to the writer. None of the others seems to require food, but all are greedy for water when they first emerge, and will eagerly lap up any drops of moisture supplied (1).

The breeding cages used in the experiments detailed below consisted of glass tubes, three inches in length by one in diameter, and these were plugged by corks through each one of which a hole a quarter of an inch in diameter had been bored. These holes were covered by fine gauze and sufficed to ventilate the tubes. Throughout the experiments cowpeas of the variety known in South Africa as *Swartbekjes* were used for rearing the larvae. All three species breed readily in this variety, and the seeds are fairly large and convenient to handle ; also the white integument is a decided advantage, as the cells containing adult weevils show up as conspicuous, discoloured patches on the white background. In making the crosses, only males and females freshly cut from their cells were used, hence there was never any doubt as to whether pairing had taken place prior to the isolation or not. A blade of grass, smeared with a few drops of a mixture of honey and water, was placed in each tube as each pair was isolated, and beyond this no further attention was given to them for four or five weeks. By this time the eggs had been deposited and the adults had died. The latter were then removed and mounted on cardboard points and labelled for future examination. The dozen or so cowpeas in each tube supplied ample nourishment to bring the F_1 generation to maturity, hence no further work was involved until the F_1 adults were ready to emerge from their cells. The F_1 adults were cut out of their cells and mated as required, and finally mounted and labelled after their death ; and so on for the succeeding generations.

The beetles have a habit of shamming death when disturbed, and this habit is very useful when specimens are being examined under the lens prior

to making up the pairs. There is no need to etherise the bruchids, as is the case with *Drosophila ampelophila* and other insects. *Drosophila* has been widely used in America for class-work in genetics, but in the opinion of the writer certain species of bruchids are much more suitable for this type of work than *Drosophila*. They are very easy to work with, and, as will be shown in this paper, they offer some very interesting problems to the student of variation and heredity.

The males and females can be fairly easily separated in the following manner. The beetles are turned over on their backs whilst they are shamming death and the hind end of the underside of the abdomen is examined through a hand lens. In the female the posterior margin of the last sternite is more or less straight, and the tip of the pygidium is only just visible when the abdomen is viewed from above (Plate IX, fig. 1); in the male the posterior margin of the last sternite is broadly incised to receive the tip of the pygidium, which is bent under the abdomen and clearly visible when the abdomen is viewed from above (Plate IX, fig. 2).

In the course of the experiments detailed below several of the cultures were destroyed by the little mite, *Pediculoides* (*Heteropus*) *ventricosus*, Newport. This mite is a well-known parasite of various kinds of burrowing insects, and has also attracted attention on several occasions by attacking human beings and causing a serious skin eruption known as "grain itch." The adult female mite is visible to the naked eye as a shining globule, about one millimetre in diameter, and, when viewed under the lens, it is seen that this globule consists of the enormously distended abdomen, the remainder of the body looking like a minute appendage (Plate IX, fig. 3). These parasites usually limit their attacks to the larval and pupal stages of their hosts, but they will at times attack adult insects, especially when the latter are enclosed in confined spaces. In the laboratory at Rosebank the mites were very numerous during the summer months. The young females swarmed into the tubes and endeavoured to fix themselves to the weevils in them. Although the majority of the parasites were dislodged by the violent kicks of their victims, some succeeded in making their way under the elytra and attaching themselves to the soft integument on the upper surface of the abdomen. The bite of these mites seems to have a very poisonous effect on their hosts, for one of the females is capable of killing an adult weevil in about twenty-four hours.

For some time it was found impossible to keep the mites out of the culture tubes, until Mr. C. W. Mally suggested the use of corrosive sublimate. A saturated solution of corrosive sublimate in absolute alcohol was made up and the large ends of the corks were dipped in this solution. The alcohol evaporated and left a fine coating of corrosive sublimate crystals on the corks. This was found to act as an extremely efficient check on the pest,

and no further trouble was encountered after the above treatment was adopted.

The work detailed below was commenced in 1916 at the Government Experiment Station, Rosebank, and was continued at the Cedara School of Agriculture during 1919 and 1920. The writer is very much indebted to Professor J. D. F. Gilchrist, of the University of Cape Town; to Mr. C. W. Mally, Senior Entomologist; and to Dr. E. Warren, of the Natal University College, for much valuable advice and assistance in the course of this work.

Loss of Factor for Pigmentation.

Whilst the life-history of *A. obtectus* was being studied at Rosebank, large colonies of these insects were bred in beans in glass jars covered with gauze. These were kept under close observation during 1916 and 1917, and late in 1917 a few beetles were noticed in one of the jars that differed markedly from the others. The chitinous integument of a normal bean weevil is strongly impregnated with black pigment, the head, pronotum, elytra, and portions of the hind femora being dead black in colour. The abnormal individuals mentioned above were totally devoid of pigment, with the exception of the antennae and the eyes; the whole of the remainder of the chitin was of a ferruginous colour. The right elytron of a normal individual is figured in Plate IX, fig. 9, and that of the mutant in fig. 12.

Although this species of bruchid has been bred in large numbers by the writer during the past five years, this is the only instance where the origin of this mutation was observed, and no mention of such a variety has been found in the literature dealing with this weevil, a literature which is fairly extensive owing to the economic importance of the insect. About thirty individuals lacking in pigment were found in this one jar, and as all were found within a few days of one another, it seems highly probable that they were the offspring of a single pair of weevils. There was no apparent difference in the conditions under which these abnormal individuals were reared that could account for the origin of the mutation.

Several attempts were made to produce the mutation artificially. Numbers of individuals were bred in an incubator at a temperature of 37°–39° C. in the presence of excessive moisture; others were bred at the same temperature in a dry atmosphere; some were grossly overcrowded in tightly corked tubes and reared in an insufficiency of oxygen; adults were exposed to a temperature of −10° C. for varying lengths of time and then allowed to breed at room temperature; some were reared in seed that had been dried over a sand bath; whilst others were reared in seed that had been soaked in water and kept moist during the development of the larvae.

These, and other attempts, to produce the mutation artificially were all unsuccessful.

The abnormal individuals mentioned above were isolated and allowed to interbreed. Their progeny consisted of normal and abnormal individuals in about equal numbers, the normal individuals being the offspring of those females that had been fertilised by normal males before isolation. The red individuals of this generation were removed from their cells and isolated once more. These were found to breed true, and from them a pure strain of weevils devoid of pigment was obtained. Several crosses were made between normal and abnormal individuals, and the results are given in the table below. " N " indicates a normal individual, " R " a red individual; experiment No. 1 was a control.

TABLE I.—*Crosses between Normal and Red, A. obtectus.*

No.	P.	F_1.	F_1 crosses.	F_2.	
	♂ ♀				
1	N×N	269 N	10	288 N	..
2	R×N	215 N	10	191 N	68 R
3	N×R	137 N	10	156 N	51 R

Numbers obtained :—347 normals ; 119 reds.

Numbers expected :—349 normals ; 117 reds.

All the F_1 individuals were normal as regards coloration, the heterozygous individuals being indistinguishable from normal adults. The differences in the totals of the F_1 and F_2 generations from the above crosses seem to indicate that the germinal change which caused the loss of the factor for pigmentation also had some effect on the fecundity. This indication is strengthened by the fact that, during the course of these breeding tests, the red individuals took longer to reach maturity than their normal confrères. The germinal change that gave rise to the mutation apparently had a more deep-rooted physiological significance than the superficial one of coloration only.

Although this mutation was only found once in the cultures of *A. obtectus*, a similar mutation seems to be of fairly common occurrence among our indigenous bruchids. *Bruchus quadrisignatus* is a South African species that breeds in the seeds of *Acacia* spp. Normally the body is black, with the exception of four conspicuous red spots on the elytra, where the black pigment has not developed. Frequently, however, individuals are found which lack the black pigment entirely. *B. versicolor* is common at the Cape, and

breeds in the seeds of *Podalyria argentea*. It closely resembles *A. obtectus* in the pigmentation of its body, but about 20 per cent. of the individuals reared by the writer were red in colour. Other native species vary in the same way.

Meristic Variation.

Each hind femur of *A. obtectus* is armed on the underside near the distal extremity with one long spine and two shorter spines (Plate IX, fig. 4). No variation in this armature is recorded in the descriptions of this species given by Say, Crotch, Riley, Fabricius, and Baudi, yet in South Africa individuals are quite common which have one long spine and three short ones on each hind femur (Plate IX, fig. 5), and still more common are adults that have one long and two short spines on one femur and one long and three short on the other.

Apparently this variation belongs to the type of variation classed by Bateson as "meristic," and of which he says (2): "The genetic analysis of these conditions must be very difficult, but evidence of any kind regarding them will be valuable." The genetic analysis of the above-mentioned variation in *A. obtectus* was indeed found to be difficult, and so far the writer has failed to obtain any insight into the manner in which the variation is inherited; yet, as Bateson states that evidence of any kind regarding them will be valuable, the results of the breeding tests are given in the tables below. The figures were obtained whilst endeavouring to separate true-breeding strains of weevils bearing the different types of armature on their hind femora. As it is extremely difficult to make out the number of spines on the hind femora in the living insect, large numbers of pairs were isolated in the breeding tubes and, after the eggs had been deposited and the weevils had died, the hind femora were removed from the dead insects and examined under the microscope. The F_1 generation was paired off at random in the same way, and the femora examined after the adults had died. It must be confessed that this is a very unsatisfactory procedure, but it is the only practicable one under the circumstances, and it was hoped that out of a sufficiently large number of crosses a few that would breed true would be found. But such so far has not proved to be the case; no strains that breed true to one long and two short spines, or one long and three short, on each hind femur have been isolated, hence it has been impossible to make a genetic analysis of this particular variation. In the table below the individuals are classified according to the number of *short* spines on each hind femur; all the adults so far examined have had the long spine fully developed. The first figure in each column signifies the number of short spines on one femur, and the second figure gives the number on the other femur of the same individual.

TABLE II.—*Variation in Armature on Hind Femora, A. obtectus.*

No.	Parents. Classified according to number of small spines on hind femora. Males. Females.	F_1 Generation. Classified according to number of small spines on hind femora. Males. 2·2	2·3	3·3	Females. 2·2	2·3	3·3
1	2·2 × 2·2	224	64	16	108	120	20
2	2·3 × 2·2	204	124	32	144	148	44
3	2·2 × 2·3	90	42	48	108	72	36
4	2·3 × 2·3	144	60	0	78	90	18
5	3·3 × 2·2	31	23	19	52	33	11
6	2·2 × 3·3	120	82	9	95	79	20
7	3·3 × 2·3	84	63	21	63	49	49
8	2·3 × 3·3	65	25	3	34	31	27
9	3·3 × 3·3	12	14	5	9	17	8

Table III shows the numbers obtained in the F_2 generation from those crosses in which the grandparents and parents resembled one another in the number of small spines on the hind femora. Here again the numbers do not seem to fit in at all with the Mendelian scheme of inheritance.

TABLE III.—*Variation in Armature of Hind Femora, A. obtectus.*

No.	Parents. Males. Females.	F_1 Generation. Males. Females.	F_2 Generation. Males. 2·2	2·3	3·3	Females. 2·2	2·3	3·3
1	2·2 × 2·2	2·2 × 2·2	119	97	53	127	79	31
2	2·3 × 2·2	2·3 × 2·2	65	37	17	89	42	21
3	2·2 × 2·3	2·2 × 2·3	76	45	23	93	58	12
4	2·3 × 2·3	2·3 × 2·3	54	37	25	73	41	18
5	3·3 × 2·2	3·3 × 2·2	21	9	7	33	17	7
6	2·2 × 3·3	2·2 × 3·3	35	27	13	27	19	9
7	3·3 × 2·3	3·3 × 2·3	8	15	5	19	6	9
8	2·3 × 3·3	2·3 × 3·3	31	27	11	28	19	8
9	3·3 × 3·3	3·3 × 3·3	8	14	3	17	6	4

A study of the above figures suggests that the variation in the armature of the hind femora is due to environmental conditions during development: in other words, is an acquired character. Whilst this is possible, it does not seem probable, as this character is extremely stable in closely allied species. The genus *Pachymerus*, for example, is characterised by a number of small spines on each hind femur. Eight specimens of *P. interstinctus*, Fahreus, and five specimens of *P. longus*, Pic, examined by the writer showed no variation in this character. Furthermore, one of the chief specific differences between *B. pisorum*, Lin., and *B. rufimanus*, Boh., is the length of the spine on the hind femur, and in these two species this character does not vary. The armature on the hind femora of *C. chinensis*, Lin., and *B. quadrimaculatus*, Fabr., was also examined for variations, but although large numbers of specimens were examined no variability was found. Hence it seems improbable that a character which is very stable in these species should be caused to vary by environmental conditions in *A. obtectus*.

Hewitt found a similar variation in the number of teeth on the pectines of certain species of scorpions (3). His remarks concerning this variation in the number of pectinal teeth may be quoted here as being applicable to the case of *A. obtectus*. He says: "The asymmetry and other variation met with among the individuals of a newly born litter may conceivably be the results of inequalities of nutrition during the prenatal period, but most probably it arises from true germinal variation."

Variation in Callosobruchus chinensis, Lin.

C. chinensis was made the subject of a long series of breeding experiments to test the inheritance of chitin colour, fecundity, and size. These experiments extended over four years, and large numbers of individuals were reared and studied. The adult of this species is a handsome beetle, 3–4 mm. in length. The colour of the chitinous integument of the body is exceedingly variable, and an examination of a long series of specimens leads one to suppose that the variatión is continuous, consisting of minute fluctuations grading imperceptibly one into the other; but breeding tests soon reveal the fact that this is not a case of continuous variation. The first four or five joints of the antennae are testaceous; the remaining joints may be testaceous, fuscous, or black (Plate IX, figs. 13–16). The head may be ferruginous, ferruginous and black, or wholly black, and the prothorax varies in the same way. The elytra are mainly ferruginous, variegated with more or less black. In the females the black areas are generally extensive, and occupy most of the posterior half of the elytra, and in some are continued in a narrow belt along the suture towards the pronotum (Plate X, figs. 18–21; only the right elytron is shown). Some females have

the black areas very restricted and some lack the black pigment altogether, but the latter are rare in a mixed population. The males have much less pigment developed in their elytra than the females as a rule, and it is generally limited to a few oblong black spots on the posterior half of the elytra (Plate X, figs. 26–29). Males with wholly ferruginous elytra are common. Females generally have two black spots on the pygidium which vary greatly in size and shape (Plate X, figs. 23–25). These spots are lacking in the males, or at best are only feebly indicated by slight infuscations.

The first experiments with this species were planned to determine whether close inbreeding would have any effects on the variations. A large number of weevils were reared from eggs deposited on cowpea pods in the field, and from these twenty pairs were isolated in the breeding tubes described above. The remainder formed the stock culture, and were allowed to breed promiscuously in cowpeas kept in a large, gauze-covered jar. The progeny of the isolated pairs were inbred for five generations, brother and sister being mated together in every case. The five generations were reared between the 7th May 1917 and the 26th June 1918, all the insects being kept at room temperature in a room that was never artificially heated in any way. The first two generations differed in no way from the individuals in the stock culture or from those that developed from eggs laid in the field. The adults of the third generation differed only slightly from normal individuals. *C. chinensis* has a small oblong patch of white scales on each elytron near the suture, but the third generation nearly all lacked this: the tendency in all of them seemed to be for the small areas of white scales to become brown, like the scales covering the surrounding areas. On the black patches of the elytra the scales are black, and these retained their black colour in the inbred specimens.

In the fourth generation there was a marked diminution in size, and 3 to 4 per cent. of the adults had elytra that failed to expand properly and were, in consequence, slightly crumpled. This latter condition reminds one of the "club wing" mutant in *Drosophila ampelophila*. The fertility was also slightly impaired in this generation. The average number of eggs per female is fifty-seven (based on over one hundred counts), but the twenty pairs isolated from the fourth generation laid only an average of forty-seven eggs per female. They also took longer to go through their life-cycle than did a corresponding generation in the stock culture.

The fifth generation showed a very rapid falling off in vigour. The adults were small and feeble, and about 25 per cent. of them died in their cells without attempting to emerge. About 10 per cent. had crumpled elytra, and several of the remainder showed irregularities in the striae of the elytra (Plate X, fig. 26). The females of seven of the twenty pairs died without

ovipositing at all, and the others were only induced to oviposit when placed in an incubator maintained at a temperature of 24°–27° C. This generation emerged during a spell of cold weather, from the 15th June to the 26th June 1918. The most striking feature about this fifth generation, however, was the blurred and indecisive character of the markings. The black patches seemed to have "run" at the edges into the ferruginous area, and at the same time they had decreased in size. The black spots on the pygidium did not suffer the same deterioration, they were as clear cut and well defined as in the earlier generations. The scaly covering was inconspicuous and could barely be detected, even with the aid of a strong hand lens. An examination under the microscope showed that the scales were smaller and sparser than in normal specimens. This poor development of the scales gave the adults of the fifth generation a smooth, shiny appearance.

Much of the above deterioration was probably due to inherent weaknesses in the original stocks, for twenty pairs of *A. obtectus*, inbred in exactly the same manner, did not show any such signs of degeneration at the fifth generation. The observations given above, however, serve to show that *chinensis* can be safely inbred as far as the F_2 generation, but that beyond this confusion is liable to arise through the stock being weakened by continued inbreeding.

An endeavour was next made to isolate strains that bred true to certain types of coloration. This was found to be a long and tedious process, for two reasons. The variations in the colour of the antennae, elytra, and pygidium of this species form a continuous series, and it is impossible to separate a mixed population into types by inspection only. Also the extent of the development of the black pigment is affected by the sex of the individual; a male and a female having the same genetic constitution do not have the same markings. Large numbers of adults were cut from their cells just as they were ready to emerge, and these were separated into groups of a dozen or so individuals, the members of each group resembling each other in the character of their markings. Many groups were isolated in this way and placed on clean *Swartbekje* cowpeas in large petri dishes. The succeeding generations from these groups were carefully examined as they emerged, and the great majority were found not to breed true to type and were consequently discarded, fresh groups being made up to replace them.

The first strain to be isolated was of the type that bred true to lack of pigmentation, a strain that was named the "plain" type, and which will be spoken of as such throughout the remainder of this paper. No attention was paid to the colour of the antennae in isolating this type, as their colour varies independently of the colour of the elytra. In this culture could be found individuals with black antennae, others with fuscous antennae, and

the remainder with wholly testaceous antennae (Plate IX, figs. 13–16). The head was brown, and marked in the males with a triangular, fuscous patch on the vertex. The pronotum was brown, marked on either side of the midline with an indistinct, fuscous patch, and evenly coated with fawn-coloured scales. The double callosity in the middle of the base of the pronotum was conspicuous and densely coated with the silvery-white scales. The small scutellum was clothed in dirty-white scales. The elytra were brown and evenly covered with fawn-coloured scales, interspersed here and there with small patches of white scales. In some of the females there was a faint indication of spots near the middle of the outer border of each elytron (Plate X, fig. 18). The pygidium was brown and densely coated with yellowish scales. A few of the females had two small spots near the apex of the pygidium, similar to those shown in fig. 23, but smaller and less conspicuous. The underside of the body was somewhat darker than the upper, especially on the pectus and hind femora. The sides of the metasternum were covered with white scales and the remainder of the underside with fawn-coloured scales.

Another strain that was isolated with more difficulty was called the "chic" type, because of its strikingly neat and handsome appearance when viewed under the lens. In this strain also the colour of the antennae was not fixed, and varied considerably. The head and pronotum were similar in colour to the plain strain, with the exception that the dark areas on the pronotum were larger and more conspicuous. The whole of the distal half of the elytra of the females was dense black in colour, with an irregular row of about six small brown spots stretching across the middle of this black area (Plate X, fig. 20). The anterior half of each elytron was brown in colour and densely coated with fawn-coloured scales, interpersed with small patches of white scales. The black pigment was less developed in the males than in the females, and the markings on the hind portion of the elytra were broken up into oblong spots (Plate X, fig. 28). The black areas were thinly covered with black scales, and the small brown spots on the hind portion of the wing were clothed in bluish-white scales. The pygidium and underside of the body were marked in a similar manner to those of the plain type.

The third strain was only isolated after repeated attempts and many failures. The difficulty in this case was due to the fact that the males differ so much from the females and resemble so closely the males belonging to other types that their preliminary selection could only be made by chance. Finally, however, a third strain was secured which bred true to the following characteristics. The antennae were variable. The head was much darker in colour than in the previous types. The pronotum was almost entirely black. The elytra of the males were marked as shown in fig. 29, and the

females as shown in fig. 21. The coating of scales was less conspicuous than in the plain and chic types; in fact, individuals belonging to this type looked bare when compared with specimens of the previous two strains. The pygidium of the female was marked with two large conspicuous black spots (Plate X, fig. 25). This strain was called the "dark" type.

Many attempts were made to isolate strains breeding true to other types of coloration, but all were unsuccessful. These remaining types may be classified into four groups: an intermediate type between plain and chic, in which the females have elytra marked as shown in fig. 19, and no black spots on the pygidium; an intermediate type having similar markings on the elytra and two small round black spots on the pygidium (Plate X, fig. 23); a third intermediate type with similar elytra and two large black spots on the pygidium (Plate X, fig. 24); and a fourth type, intermediate between chic and dark, in which the female's elytra have the distal half solid black and the pygidium is marked with two small round black spots. All these types were found to be more variable than the above three types, and none would breed true.

Reciprocal crosses were made between individuals belonging to all the above types, and for the sake of brevity the results obtained are summarised in tabular form at the end of this paper. In the crosses between pigmented individuals and those lacking pigment the simple 3 : 1 ratio is obtained, but there is obviously another factor at work causing an intensification of the pigmentation in certain individuals. If the following assumptions are allowed, it will be found that the numbers obtained in the experiments conform more or less closely to the expected ratios. There are at least two factors controlling the development of the black pigment in *chinensis*: C, the factor without which no black pigment is developed; and I, the factor that causes an intensification of the pigmentation. Plain individuals lack the factor C, but may be homozygous or heterozygous for the presence or absence of I. Females in which C is present but which lack I have no spots on their pygidium; females heterozygous for the presence of I have two small spots; and females homozygous for the presence of I have two large spots on the pygidium. Individuals homozygous for the presence of both C and I belong to the dark strain, and individuals homozygous for the presence of C and absence of I belong to the chic strain. It was found necessary, in making the counts, to include females having the genetic constitution, CCIi, with the chic females, CCii, as in both these types the scaly coating on the pygidium is very dense and it is impossible to make out whether the small pygidial spots are developed or not unless the scales are removed. The males were not included in the counts given in the tables, as they lack the pygidial spots, an essential character in separating the individuals into classes. To sum up, the genetic constitution of the

different types of individuals found in the species *chinensis* seems to be as follows :—

CCII. Dark (figs. 21, 25 female, 29 male).

CCIi. Chic, with two small pygidial spots obscured by the pubescence (figs. 20, 23 female, 28 male). In the tables these are included with the next type.

CCii. Chic (figs. 20, 22 female, 28 male).

CcII. Intermediate type with large pygidial spots (figs. 19–20, 24–25 female, 27–28 male).

CcIi. Intermediate type with small pygidial spots (figs. 19–20, 23 female, 27–28 male).

Ccii. Intermediate type with no pygidial spots (figs. 19–20, 22 female, 27–28 male).

ccII, ccIi, ccii. Plain type (figs. 18, 22 female, 26 male).

The above scheme fits in well with the theory of colour inheritance in mammals put forward by Sewall Wright (4). He assumes that melanin is produced by the oxidation of certain products of metabolism by the action of specific enzymes. According to Wright, the development of colour depends on the rates of production, or of potency, of two enzymes ; enzyme I (corresponding to the factor C above) is essential to the production of any colour, and enzyme II (the factor I above) is supplementary to I and produces no effect by itself. The diagrams Wright gives to illustrate his theory are reproduced in a modified form on Plate XI, together with the interpretation applied by the present writer to the above results.

The results given in the tables at the end of this paper were obtained whilst working with strains isolated at Rosebank from weevils reared in cowpeas grown in the experimental plots. During 1920 fresh strains were isolated from material infesting cowpeas grown at Cedara, Natal. Comparatively few crosses were made with these strains, and the results confirmed those obtained with the Rosebank material except that the dark type behaved differently. When crossed with plain and with chic, these individuals gave conflicting results, for the dark type failed to show up in the F_2 generations. Unfortunately the experiments could not be carried far enough to give conclusive results ; the anomalies may have been due to the fact that some of the males of the dark strain were not homozygous for the presence of both factors, or there may have been a third factor at work in the Natal strain that was not present in the Rosebank material. The fact that more than two factors are concerned in the colour variations of *chinensis* is obvious when one compares specimens from other parts of the world with South African specimens. Mr. C. W. Mally gave the writer a number of specimens of *chinensis* that he had collected in Ames, U.S.A.,

some years ago, and in the South African Museum are a number of specimens labelled "Amandi, German East Africa, 10–12–06." All these differ markedly from specimens collected in South Africa. The pronotum and underside of the body is much darker, the black spots on the elytra are smaller and fewer, and the pygidium in both sexes is clothed in a dense white pubescence. Furthermore, the antennae of the males are strongly pectinate (Plate IX, fig. 17), whereas in this country the males have serrate antennae (Plate IX, figs. 13–16). Thus there are some very interesting regional variations found in *chinensis*, and by crossing strains from different parts of the world some very interesting results should be obtained.

Variations in Size and Fecundity.

The inheritance of variations in size was investigated, but without obtaining any results worth recording. An undersized strain was easily secured by grossly overcrowding the beetles and limiting the food-supply of the larvae. By allowing them to breed for three or four generations under these conditions a number of individuals were obtained which measured only 1–1·5 mm. in length, instead of an average of about 3 mm. These dwarfs seemed normal in every respect except size, although many of them died without giving rise to any progeny, and the remainder were by no means prolific. When placed with an ample supply of sound cowpeas the progeny of these undersized individuals were found to be of normal size, and apparently had not suffered at all by the dwarfing of their ancestors. The few crosses between dwarfed and normal individuals that proved fertile all gave rise to F_1 and F_2 generations of normal adults.

The above experiments were undertaken because of the condition found in an indigenous species, *Bruchus cicatricosus*, Fahr., which breeds in the seeds of *Crotalaria capensis*, Thunb. In this species two distinct types are found as regards size, members of the one type measuring about 5 mm. in length, and the others only about 3 mm. in length. The size in this instance seems to be independent of the food-supply, for the small individuals have been reared from pods in which there was ample food material, but it is possible that the fixation of the types has been brought about by generations of overcrowding and insufficiency of food. The larva of this species does not limit its attack to one seed, as in most other bruchids, but devours four or five seeds before reaching maturity, hence half-a-dozen larvae in one pod would soon devour all the seeds and the adults from them would be undersized owing to dearth of food.

The experiments made to investigate the inheritance of high and low fecundity were equally unsuccessful owing to the difficulty of fixing strains that bred true to these characters. As a first step, about eighty crosses were

made between vigorous individuals that developed from eggs deposited on cowpea pods in the field. Eight of these females gave seventy or more eggs each and ten gave only twenty or less each. The intermediates were discarded. Males and females from the families showing the highest fecundity were crossed, and similarly pairs from those showing low fecundity were made up. Inbreeding was avoided by mating only males and females from different families. The results were disappointing, as the average number of eggs per female from twenty-five of the high-fecundity crosses was forty-nine and from twenty-five of the low-fecundity crosses it was forty-seven. Once more the most prolific pairs of the first set were retained and those showing the lowest fecundity in the second set were also retained. Five females laid seventy eggs and more each, and four laid under twenty eggs each. From the progeny obtained from these females twenty pairs were made up as before. This second set of matings gave more promising results, as the average from the high-fecundity strain was fifty-three eggs per female, and that from the other strain was only thirty-one per female. A third set of pairs was isolated, choosing once more only the progeny of the highest and lowest producers. The result of these matings caused the attempt to isolate the two strains to be abandoned, for in this instance the average from the females descended from three generations of prolific ancestors was only thirty-nine, whereas those females descended from ancestors with low fecundity gave an average of fifty-five eggs per female.

Attempts at Hybridisation.

Many attempts were made to get *C. chinensis* and *B. quadrimaculatus* to cross. At first sight this may appear to have been an ambitious attempt to cross two species belonging to two different sub-genera, yet the two species are so nearly allied and resemble one another so closely in size, build, and habits, that the attempts were made with high hopes of success. The sub-genus *Callosobruchus* was erected by Pic, and the sole distinguishing character of this group is the conspicuous double callosity on the pronotum. There seems to be no physiological reason why the possession of this characteristic should render crossing with a nearly allied species impossible.

Large numbers of virgin females of both species were isolated in gauze-covered jars containing fresh, sound cowpeas. Equal numbers of males were placed with the females, *chinensis* males being confined with *quadrimaculatus* females, and vice versa. The males in both jars were seen to make repeated attempts to copulate, but none apparently succeeded, for although a few eggs were laid, none proved fertile. It was only when the genitalia of the males were examined that this failure to copulate success-

fully was understood. There are remarkable differences in the size and shape of the internal sac in the males of the different species of bruchids, and especially marked are the differences between *chinensis* and *quadrimaculatus* in this respect. The internal sac of the male *chinensis* is a long tubular structure armed at the end with six large chitinous teeth and two small palp-like appendages (Plate X, fig. 30); in *quadrimaculatus* it is more or less spherical, and armed with numerous thinly chitinised hairs that project backwards, and with two tubular evaginations near the base (Plate X, fig. 31). Normally these sacs are withdrawn into the genital tube and their shape and structure cannot be made out, but if a large number of males are examined a few will generally be found that have died with their sacs evaginated, and these can be easily dissected out and examined.

Other Variations among the Bruchidae.

Besides the two types of *A. obtectus* already mentioned, individuals with only a partial pigmentation of the elytra are occasionally met with (Plate IX, figs. 10 and 11). Normally the underside of the hind femur in this species is dead black in colour, but this character is very variable, as shown in Plate IX, figs. 4–8. The pigmentation of the underside of the abdomen also fluctuates within wide limits. All these variations offer an interesting field for investigation, but the work would be difficult owing to the fact that it is practically impossible to determine accurately the extent of the pigmentation in the living individual, mainly because of the coating of scales. The pairs would have to be made up more or less at random, and the insects dissected after death, in order that the various parts might be examined under the low power of the microscope by transmitted light.

The abnormalities in the femoral armature of *A. obtectus*, shown in Plate IX, figs. 5–8, were occasionally met with in the course of the studies detailed in the section of this paper headed "Meristic Variation": the inheritance of these aberrant forms was not investigated.

Certain irregularities in the striation of the elytra were often met with (Plate X, fig. 26), especially among individuals of *B. quadrimaculatus* and *B. spadiceus*. *B. quadrimaculatus* also presents considerable variation in the extent of the pigmentation of its elytra of a similar nature to the variation in *C. chinensis*, only the distribution of the pigment is different.

Throughout the sub-family Bruchinae (which includes 815 of the 818 species included in the Bruchidae) the ground colour of the chitin is testaceous or ferruginous, and in most of the species there is a secondary development of black pigment. Not only is the extent of this pigmentation very variable, but the manner in which it is distributed in the different species is very

diverse. For example, the black pigment, when present, forms two spots on the apex of the pygidium of the females only in *chinensis*, but of both sexes in *decoratus* ; in *quadrisignatus* it forms a triangular patch of varying size along the base of the pygidium in both sexes ; in *varicolor* the pygidium has an irregular black border around a testaceous centre ; on the elytra of *quadrisignatus* there are four conspicuous areas devoid of black ; in *varicolor* there is an irregular black border round each elytron ; in *albosparsus* and *spadiceus* the black pigment forms a triangular patch along the elytral suture ; and so on. The factor (or factors) determining the presence or absence of the black pigment seems to be of a similar nature throughout the whole sub-family, but apparently there is a great diversity in the factors controlling the distribution of this pigment. The vigour of the individual also has some effect on the nature of its colouring ; vigorous individuals have the pigment slightly better developed than weakly individuals ; the colour is deeper and the edges of the black areas are more clearly defined in the former, whereas in the latter the colour is often deep brown instead of black and the edges are blurred and indecisive.

Summary and Conclusions.

1. *A. obtectus*, *C. chinensis*, and *B. quadrimaculatus* are excellent subjects for experimental breeding purposes, as they copulate and oviposit freely in confined spaces and require very little attention throughout their whole life-cycle.

2. A mutation was found among some bean weevils, *A. obtectus*, bred in dwarf beans in gauze-covered jars. The mutant differed from normal individuals in lacking the black pigment which is strongly developed in the chitinous integument of the latter, and this lack of pigmentation was found to be recessive to the normal condition, the simple 3 : 1 ratio being obtained in the F_2 generation.

3. The armature on the hind femora of *A. obtectus* varies somewhat. Normal individuals have one long and two short spines on each hind femur, but individuals with one long and three short spines on each hind femur are common, and others with one long and two short on the one femur and one long and three short on the other occur still more frequently. Attempts to isolate strains breeding true to these characters were unsuccessful, and the numbers obtained in the course of these attempts did not apparently conform to the Mendelian scheme of heredity.

4. The markings on the elytra of *C. chinensis* are very variable, as are also the pygidial spots of the females. At the one end of the scale we have individuals that are lacking in black pigment, and at the other individuals

that are almost entirely black. These two extremes are connected by a number of intermediate types, and at first sight the variation appears to be continuous. Experimental breeding showed, however, that certain true-breeding strains could be isolated, and that the colour variations were due to the interaction of at least two factors which are inherited in accordance with the Mendelian scheme.

5. Size and fecundity are also very variable characters in the Bruchidae. Attempts to obtain an insight into the mode of inheritance of these characters were unsuccessful.

6. Attempts to hybridise *chinensis* and *quadrimaculatus* were also unsuccessful. Inter-specific crossing is prevented among the Bruchidae by the remarkable differences in the size, shape, and structure of the internal sacs of the males.

7. Specimens of *chinensis* from America and from East Africa differ from South African types in the nature of the antennae of the males, of the markings on the elytra, and of the scaly covering on the pygidium. Crosses between material obtained from overseas and South African specimens should give interesting results.

Tables showing Results of Crosses between Various Types of Chinensis.

Table IV.—*Crosses between Plain and Chic, ccii × CCii, F_1 females intermediate, with no pygidial spots, Ccii.*

No.	No. of F_1 pairs.	Total No. of offspring.	F_2 generation.		
			Chic.	Intermediate. No spots.	Plain.
1	5	89	20	46	23
2	7	143	35	75	33
3	5	72	19	32	21
4	4	79	19	38	22
5	8	157	37	80	40
6	5	111	29	54	28
7	5	53	14	26	13
8	3	78	18	41	19
Totals .	42	782	191	392	199
Expected Nos. .		782	195·5	391	195·5

TABLE V.—*Crosses between Plain and Dark, ccii × CCII, F_1 females intermediate, with small pygidial spots, CcIi.*

No.	No. of F_1 pairs.	No. of F_2 ♀ offspring.	F_2 generation (females only).					
			Dark.	Chic.	Inter. Large spots.	Inter. Small spots.	Inter. No spots.	Plain.
1	6	47	2	10	5	11	7	12
2	4	38	2	7	6	11	3	9
3	8	79	5	14	10	19	10	21
4	7	42	2	8	6	10	5	11
5	5	32	1	6	5	8	3	9
Totals	30	238	12	45	32	59	28	62
Expected Nos.		238	15	45	30	60	30	60

TABLE VI.—*Crosses between Plain and Dark, ccII × CCII, F_1 females intermediate, with large pygidial spots, CcII.*

No.	No. of F_1 pairs.	No. of F_2 ♀ offspring.	F_2 generation (females only).		
			Dark.	Intermediate. Large spots.	Plain.
1	5	39	8	21	10
2	9	97	19	49	29
3	7	48	12	25	11
Totals .	21	184	39	95	50
Expected Nos. .		184	46	92	46

TABLE VII.—*Crosses between Chic and Dark, $CCii \times CCII$, F_1 females chic, with small pygidial spots, $CCIi$.*

No.	No. of F_1 pairs.	No. of F_2 female offspring.	F_2 generation.	
			Dark.	Chic.
1	3	56	12	44
2	5	97	23	74
3	5	63	15	48
4	5	108	27	81
5	3	48	10	38
6	5	76	18	58
7	4	68	19	49
8	5	83	20	63
9	5	91	22	69
10	5	47	12	35
11	4	56	15	41
12	5	115	28	87
Totals . .	54	908	221	687
Expected Nos. . .		908	227	681

TABLE VIII.—*Crosses between Plain and Chic, $ccII \times CCii$, F_1 females intermediate, with small pygidial spots, $CcIi$.*

No.	No. of F_1 pairs.	No. of F_2 ♀ offspring.	F_2 generation.					
			Dark.	Chic.	Inter. Large spots.	Inter. Small spots.	Inter. No spots.	Plain.
1	7	65	3	13	8	18	9	14
2	7	49	3	10	5	14	6	11
3	5	57	2	12	7	16	8	12
Totals	19	171	8	35	20	48	23	37
Expected Nos.		171	11	33	22	44	22	44

CROSSES GIVING A MIXTURE OF TYPES IN THE F_1 GENERATION.

TABLE IX.—*Crosses between Plain and Chic, ccIi × CCii.*

No.	No. of F_1 generation.	No. of F_1 females.	F_1 females.	
			Intermediate. Small spots.	Intermediate. No spots.
1	9	5	3	2
2	28	14	9	5
3	37	17	9	8
4	21	12	5	7
5	15	8	4	4
6	19	11	5	6
Totals . .	129	67	35	32
Expected Nos. . .		67	33·5	33·5

TABLE X.—*Crosses between Plain and Dark, ccIi × CCII.*

No.	No. of F_1 generation.	No. of F_1 females.	F_1 females.	
			Intermediate. Large spots.	Intermediate. Small spots.
1	29	12	8	4
2	27	15	5	10
3	45	21	12	9
4	11	4	3	1
5	28	19	4	15
6	26	11	4	7
Totals . .	166	82	36	46
Expected Nos. . .		82	41	41

(The F_2 generations from the crosses shown in Tables IX and X gave rise to the types that were expected in accordance with the scheme given above.)

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EXPLANATION OF PLATES.

Plate IX.

Fig. 1. Underside of abdomen of *A. obtectus*, female.

Fig. 2. Underside of abdomen of *A. obtectus*, male.

Fig. 3. *Pediculoides ventricosus*, Newport, adult female.

Figs. 4–8. Variations in hind femora, *A. obtectus*.

Figs. 9–12. Variations in pigmentation of elytra, *A. obtectus* (only the right elytron is shown in each case).

Figs. 13–16. Variations in pigmentation of antennae, *C. chinensis* (the left antenna of the male is shown in each case).

Fig. 17. Left antenna of male *chinensis* from the United States.

Plate X.

Figs. 18–21. Right elytron of female *chinensis*, showing variations in pigmentation.

Figs. 22–25. Pygidium of female *chinensis*, showing variations.

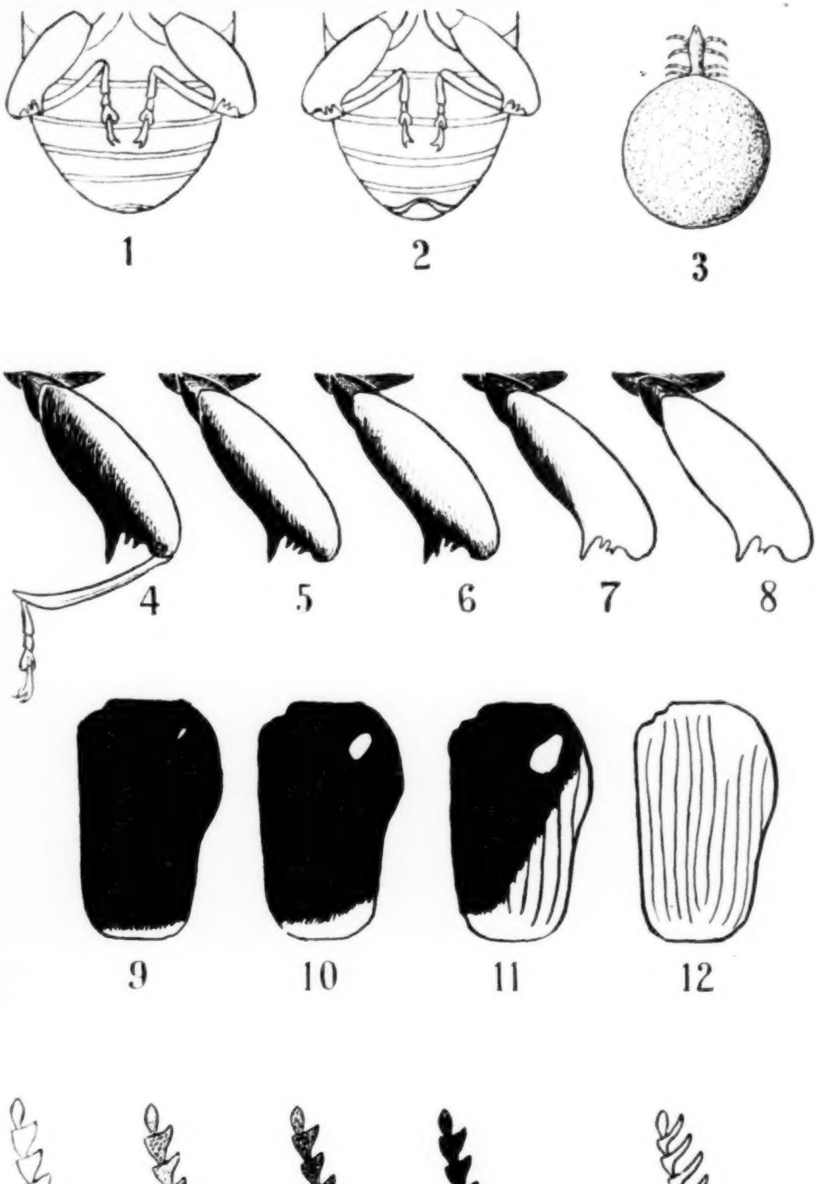
Figs. 26–29. Right elytron of male *chinensis*, showing variations.

Fig. 30. Male genital tube, *C. chinensis*, showing internal sac.

Fig. 31. Male genital tube, *B. quadrimaculatus*, showing internal sac.

Plate XI.

Right elytron of male, and right elytron and pygidium of female, showing types of markings corresponding to the several combinations of the factors C and I. Diagrammatic scheme adapted from Sewall Wright.



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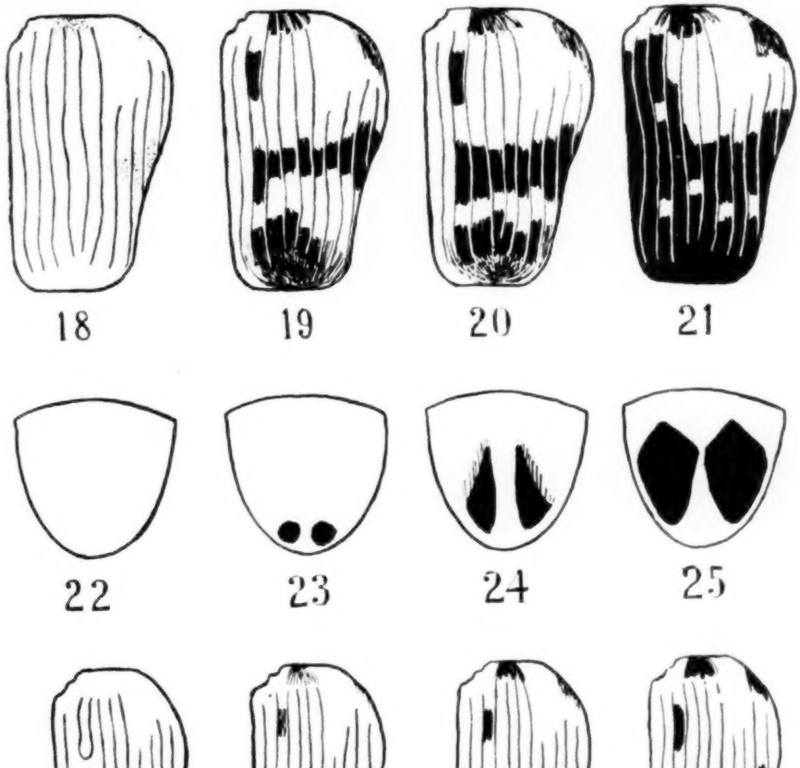

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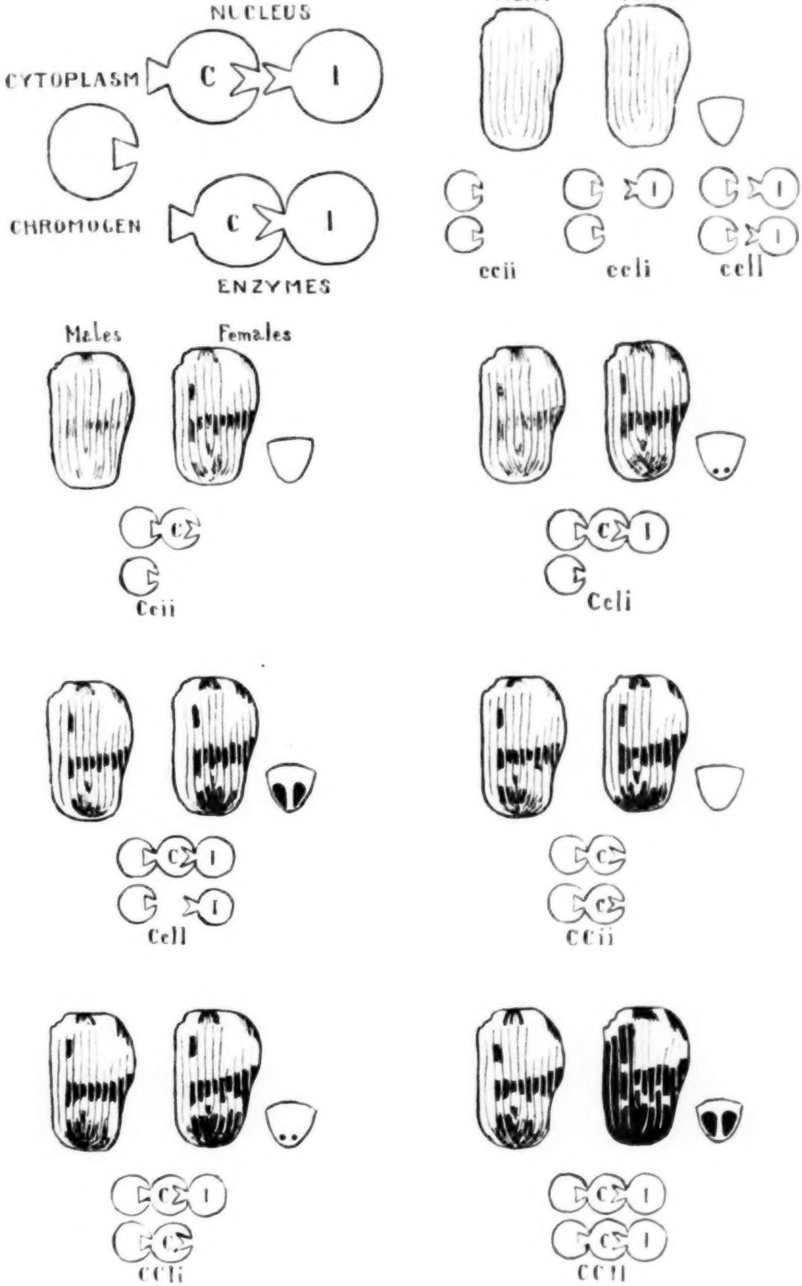
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A NEW TRICHOSTRONGYLUS FROM SOUTH AFRICAN SHEEP.

By H. O. Mönnig,

Veterinary Research Officer, Onderstepoort, Pretoria.

(With three Text-figures.)

Preliminary Note.

In the course of researches on the problem of Trichostrongylosis in South African sheep three species of Trichostrongylus have so far been encountered, viz. *T. extenuatus*, which occurs in the abomasum and is not very frequent, *T. instabilis* and *T. rugatus* n. sp., which occur, often together, in the first 8–12 feet of the small intestine, while the former is occasionally also found in small numbers in the abomasum. These latter two species are very frequent in some parts of the country, where they cause heavy losses.

The results of researches on the life-histories, effects, prevention, and treatment of these parasites will be published in the Reports of the Director of Veterinary Education and Research.

Trichostrongylus rugatus n. sp.

The worms are small and slender, of a slightly brownish-red colour. The body is gradually attenuated forward in the anterior half; the head is 12 μ wide, the mouth opening circular, with three very inconspicuous lips surrounded by small punctiform papillae. The cuticle has fine annular striations, about 3·6 μ apart, in the middle of the body. Cervical papillae are absent. The excretory pore lies in a conspicuous ventral depression, 130 μ from the anterior end. The nerve ring is situated a short distance behind the level of the excretory pore. There is no clearly differentiated buccal cavity; the oesophagus is long and simple, measuring 900 μ in the male and 903 μ in the female.

The male is 4·5–6·6 mm. long and about 80 μ thick in front of the bursa. The testis is simple and uncoiled. The bursa has large lateral lobes and a very small median lobe, and is supported by six rays in each lateral lobe. The ventro-ventral ray is slender, and reaches nearly to the edge of the bursa; it is directed ventrad, and is far apart from the latero-ventral ray, which is directed more laterally and runs together with the lateral rays

and is also much thicker than the ventro-ventral ray. The externo-lateral ray is about as thick as the latero-ventral, but ends abruptly with a small knob-like extremity and does not quite reach the margin of the bursa. The medio-lateral ray runs close to the externo-lateral, but is thinner and reaches the edge of the bursa ; the tips of these two rays are closer together than those of any of the others. The postero-lateral ray is thin, diverges from the medio-lateral, and also reaches the edge of the bursa. The externo-

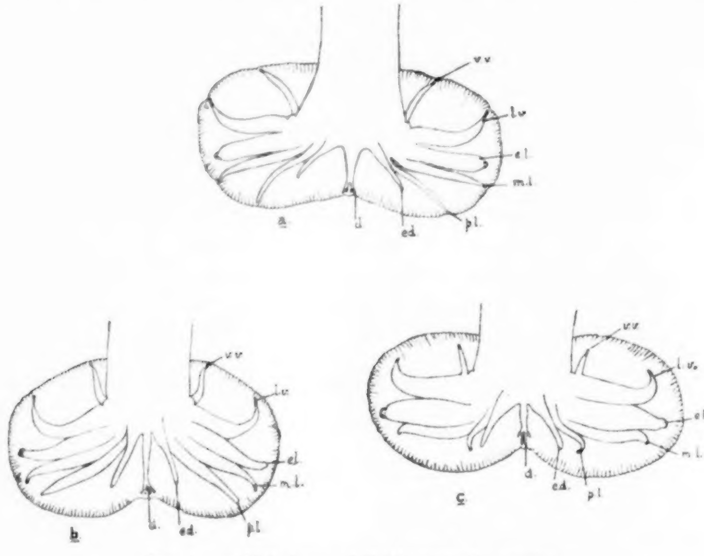


FIG. 1.—*a.* Male bursa of *Trichostrongylus rugatus.*
b. ,, ,, ,, *extenuatus.*
c. ,, ,, ,, *instabilis.*

dorsal ray is thin and short, about half as long as the postero-lateral. The dorsal is relatively long and divided near its end into two branches which each again bifurcate. The spicules are yellowish brown and conspicuous, differing in size and shape. The left is 141–152 μ long, and has roughly the shape of an elongate equilateral triangle with the base anteriorly ; the right is 137–145 μ long and has a more rectangular shape. There is an angular projection, slightly bifid, on the ventral surface of each spicule posteriorly, and beyond this each spicule ends in a drawn-out process slightly enlarged at its extremity ; this process stands at a smaller angle to the long axis of the spicule in the case of the left than in that of the right. A conspicuous feature of this species is a series of transverse ridges over the

ventral surfaces of the spicules, hence also the name "rugatus." Each spicule bears a knob-like process on its anterior end. The gubernaculum is similar in colour to the spicules, and measures 86·4 μ in length ; in shape it resembles roughly a sickle whose anterior part has been bent straight ; it is widest in the middle of its length. Prebursal papillae are very small, and can only be seen with difficulty.

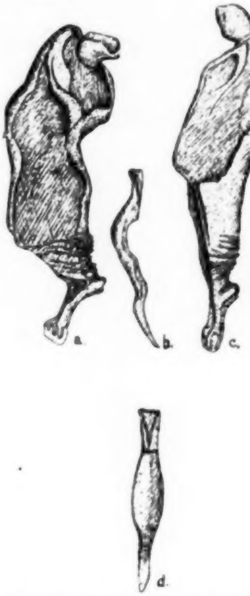


FIG. 2.—*Trichostrongylus rugatus.*
a. Right spicule, right lateral view.
b. Gubernaculum, ,, ,, ,,
c. Left spicule, ,, ,, ,,
d. Gubernaculum, ventral view.

The female is 5·8–7·3 mm. long and 79 μ wide in the region of the vulva ; the latter is placed 1·25 mm. from the tip of the tail and is a longitudinal slit, 50–55 μ long, surrounded by prominent chitinous lips. Sphincters and ovijectors are strongly developed, one lying anteriorly and one posteriorly, their combined lengths averaging about 450 μ. The uteri contain usually about 12 eggs each, which measure 80–86 $\mu \times$ 43–46 μ and are laid in the 8–16-celled stage. The ovaries lie in wavy lines but are not coiled. The body becomes but slightly thinner from the vulva to the anus ; behind the latter it narrows suddenly and ends in a narrow sharp tail which is sometimes bent slightly dorsalwards. The tail is 55–70 μ long.

It is very difficult and usually practically impossible to distinguish the females of *Trichostrongylus rugatus* from those of *T. instabilis* as, with the exception of the differences in size, they are practically alike; the differences in size vary much in each species, and as only the *average* length of *T. instabilis* females is less than that of *T. rugatus* females, this feature is also of little value for diagnostic purposes. The males can be more easily distinguished. *T. rugatus* can be readily recognised by the ridges on the ventral sides of its spicules. It differs further from *T. instabilis* in the greater length of the postero-lateral ray of the bursa and in the fact that the spicules

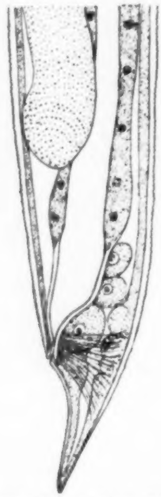


FIG. 3.—*Trichostrongylus rugatus*—hind end of female.

are dissimilar; from *T. extenuatus* it differs in the shape of the spicules and gubernaculum and in the fact that the postero-lateral ray is more slender and that its tip is far apart from that of the medio-lateral ray, whereas in *T. extenuatus* the tips of these two rays are relatively close together. *T. rugatus* takes an intermediate position between *T. extenuatus* and *T. instabilis* in a number of points as regards its spicules and also its bursal rays, as can be seen from fig. 1.

In the case of *T. falculatus* Ransom, 1911, there is a closer similarity, and it was considered advisable to make sure that these two species are not identical. Material of *T. rugatus* was accordingly sent to Professor Ransom, who kindly compared it with his type specimens of *T. falculatus*, and came to the conclusion that " the shape of the spicules as indicated by the drawing of *T. falculatus* is very different in detail from that of *T. rugatus*, including

the absence of the ridges, which are conspicuous features of the latter species," while besides the spicules of *T. falculatus* are shorter. This material of *T. rugatus* was placed in the U.S. National Museum, Helminthological Collection, No. 26112. Comparing Ransom's description and drawing of the bursa of *T. falculatus* * with that of *T. rugatus*, there seems to be very little difference; the two species could, however, be distinguished by the differences in the spicules mentioned above and by the fact that the spicules of *T. rugatus* are not similar in shape and size as in *T. falculatus*.

* B. H. Ransom, "Two New Species of Parasitic Nematodes," Proc. U.S. Nat. Mus., vol. xli (1911), pp. 363–369.

FACTS AND THEORIES ON THE DISTRIBUTION OF SCORPIONS IN SOUTH AFRICA.

By John Hewitt.

(With six Text-figures.)

The following paper has been written mainly for the purpose of showing the connection between two classes of facts, viz. the inter-relationships of the various members of a natural group of animals, and the geographical distribution of those members. The data for such studies are comparatively simple in the scorpions. This is partly owing to their sluggish habit and very limited means of distribution, whereby the geographical relations of the various forms to each other remain in better conformity with the original arrangement than in many other groups. It is also in part a result of a general lack of plasticity amongst scorpions: thus, our conception of genetic relationships is not obscured by a confusing array of highly specialised forms, as in so many groups of insects. Further, we have the satisfaction of knowing that this is one of the few groups of animals whose distribution has not been greatly disturbed by the operations of man, at any rate in the drier parts of our subcontinent: exception may have to be made in the case of the savannah fauna of East Africa, where the tall and luxuriant grass is subject to annual fires, and possibly the genus *Opisthacanthus* is accidentally distributed in timber. Lastly, we are dealing with a fauna whose species in all probability were evolved in this region for the most part.

There are two different views on the mode of dispersal of a natural group of animals. Some zoologists believe that the most primitive members of a group remain at its centre of origin whilst successively newer and higher forms radiate therefrom far and wide: others hold that the primitive members themselves migrate or are driven to the ends of the earth far away from the centres of origin and dispersal, which become monopolised in turn by the more successful higher types. There is undoubtedly an element of truth in both views, but the latter is here accepted as the main principle, for it affords the only satisfactory explanation of the more important facts of distribution in the family Scorpionidae. Besides, it is highly improbable that South Africa can have been the centre of origin for all the many genera of animals which have their simplest forms in this

subcontinent. On the whole, the distribution of scorpions lends support to the general conclusions formulated by Dr. W. D. Mathew in his well-known paper on "Climate and Evolution."

Family BUTHIDAE.

This family is represented by five genera in South Africa. Two of them, *Parabuthus* and *Buthus*, are entirely composed of scorpions which are large or fairly large in bodily size: the other three, *Uroplectes*, *Pseudolychas*, and *Karasbergia*, are all of small or moderate bodily size. Amongst related forms of scorpions, it seems to be a general rule that primitive characters and small bodily size are associated together; and in this particular case there is indeed good evidence for that belief. It seems reasonable to suspect specialisation in all those positive characters which are completely absent from the various groups of the Scorpionidae, and present in some but not all of the Buthid genera. On such grounds we may tentatively consider the small teeth on the inferior edges of the immovable finger of the mandible in *Buthus* and *Parabuthus* as specialised characters, and their absence in *Karasbergia* and *Uroplectes* as the more primitive condition.

After careful study of the characters of the chelicerae in various African scorpions, I am satisfied that the simplest and presumably most primitive condition is that of the Scorpionid genera, *Scorpio* and *Opisthophthalmus*. Here there is a single continuous row of strong teeth in both movable and immovable jaws, terminating in each case in a single terminal fang: the tooth next to the latter in the movable jaw is fairly large, but not fang-like, nor separated by a deep groove from the fang itself. In *Pandinus*, this distal tooth is no longer an ordinary cutting tooth, but is elongated and somewhat fang-like, though much smaller than the terminal fang; and there is a more or less pronounced groove between it and the terminal fang into which the fang of the immovable finger fits. In *Cheloctonus*, *Opisthacanthus*, and *Hadogenes*, the distal tooth of the movable finger is so large that this segment has two strong fangs of nearly equal size, and between them is a deep groove into which the fang of the immovable finger fits. In *Uroplectes* and *Karasbergia* likewise, the movable finger has two long and strong fangs, and further, there is a pair of accessory teeth on the inferior side in a line with the original terminal fang: these are smaller than the primary teeth, and not so heavily chitinised nor so darkly pigmented. The immovable finger is, however, unmodified.

Lastly, in *Parabuthus* and *Buthus* the movable finger is specialised as in *Uroplectes*; and in addition, the immovable finger has a pair of accessory teeth (or three) in a corresponding position to those of the movable finger.

Thus, on the chelicera characters, *Buthus* and *Parabuthus* represent the highest degree of specialisation : and, so far as I know, there is no evidence to conflict with the view that the other forms mentioned are primitive in their simplicity. This character was considered by Pocock in his valuable paper "On the Classification of Scorpions" (Ann. Mag. Nat. Hist., 6, xii, p. 303, 1893), but no generic differences in the subfamily Scorpionini were mentioned therein. According to that paper, the Australian groups Bothriuridae and Urodacini are the only other groups of scorpions possessing the simple type of dentition found in the Scorpionini.

Chelicerae of *Opisthophthalmus latimanus*, 1; *Pandinus magrettii*, 2; *Hadogenes troglodytes*, 3; and *Parabuthus transvaalicus*, 4. Dorsal view 1–3; ventral view 4, showing accessory teeth on both jaws.

In general harmony with these conclusions, are the results of a study of the structure of the lung-books. This was worked out by Dr. M. Laurie (see Ann. Mag. Nat. Hist., 6, xvii, p. 192, 1896, and 6, xviii, p. 122), who showed that the simplest type of lung lamella is that found in the families Scorpionidae (except Diplocentrinae), Bothriuridae, certain Vejovidae, and the neotropical subfamily Chactinae. A slightly more advanced type is that found in the Diplocentrinae, the subfamily Euscorpiinae of the Chactidae, and the genera *Jurus* and *Caraboctonus* amongst the Vejovidae. The most advanced type is that of the Buthidae, and the oriental family Chaerilidae.

It should be added, however, that, according to the same authority, the family Scorpionidae differs from all others in its mode of development, the eggs being minute and yolkless, whilst the Buthidae and other families have eggs of considerable size owing to the large quantity of contained yolk : the latter condition was held to be the most primitive. On this character, the Urodacini seemed to be the lowest of the various subfamilies of the Scorpionidae, whilst *Opisthophthalmus* was held to be specialised on account of its peculiar outgrowths from the head in the embryo.

Again, there are good grounds for regarding the pentagonal shape of the

sternum in *Karasbergia* as primitive, inasmuch as we know from the work of Petrunkevitch (American Naturalist, vol. l, Oct. 1916) that the triangular sternum of *Centrurus* (Buthidae) passes through a pentagonal stage in the course of its development.

With regard to the carination of the tail and body, there is a strong general resemblance between the caudal crests of *Parabuthus* (fam. Buthidae) and those of *Opisthophthalmus* (fam. Scorpionidae), and some of the Palaeozoic scorpions were also strongly crested in their tails: we may therefore look upon the crested condition in modern Buthids as more primitive than the non-crested, rather than appeal to independent and convergent evolution for an explanation of the similarity in two distinct families. The primitive condition in caudal segments I–IV seems to be 10-keeled: we find this in several species of *Uroplectes*, *Parabuthus*, and *Buthus*, but not in all species of those genera. On the other hand, *Opisthophthalmus* is only 8-keeled on these segments, but may have been originally 10-keeled, for there is still a very faint trace of the lost middle lateral keel distally, a solitary bristle marking the position of the lost keel on each segment.

Nevertheless, there seems not the slightest reason for regarding the carination of the carapace as primitive: in this respect, *Buthus* should certainly be considered the most specialised of all the genera. Strongly tricarinate tergites, as found in *Buthus*, also seem to be specialised, for nothing of the kind is known in the Scorpionidae, nor in the few known fossil forms; but there is no data to show whether the incipient lateral keels found in most species of *Uroplectes* are secondary or primitive.

Buthus Leach.—This genus, undoubtedly very specialised in several important characters, and quite unique in the keeling of the carapace, is widely spread from the Mediterranean region to China, and practically throughout Africa extending southwards to Little Bushmanland in the west, and Zoutpansberg district on the east side. In South Africa, however, it is comparatively rare, and the species incompletely known. The southernmost species, *B. arenaceus* Purcell of Little Bushmanland, and *B. conspersus* Thorell from "Caffraria," are only known from the type specimens. They are remarkable in possessing a low number of pectinal teeth, 14 in *conspersus*, and 17–18 in *arenaceus* (♀): whereas, *trilineatus* Ptrs., a common East African species extending southwards to the Transvaal, has 25–27 pectinal teeth. These three are the only species known from South Africa, but the few other species belonging to the Ethiopian region proper are quite closely related to *trilineatus*, and *B. emini* Poc. from Victoria Nyanza may not be specifically distinct therefrom. The greatest differentiation of this genus undoubtedly occurs in the northern hemisphere, whilst the two most southern species are apparently generalised ones; indeed, in all the Ethiopian species caudal segment IV has the primitive condition of

10 crests, as in segments I–III, whereas most of the northern species have only 8 crests on that segment. On these data, it seems very probable that *Buthus* is of northern origin.

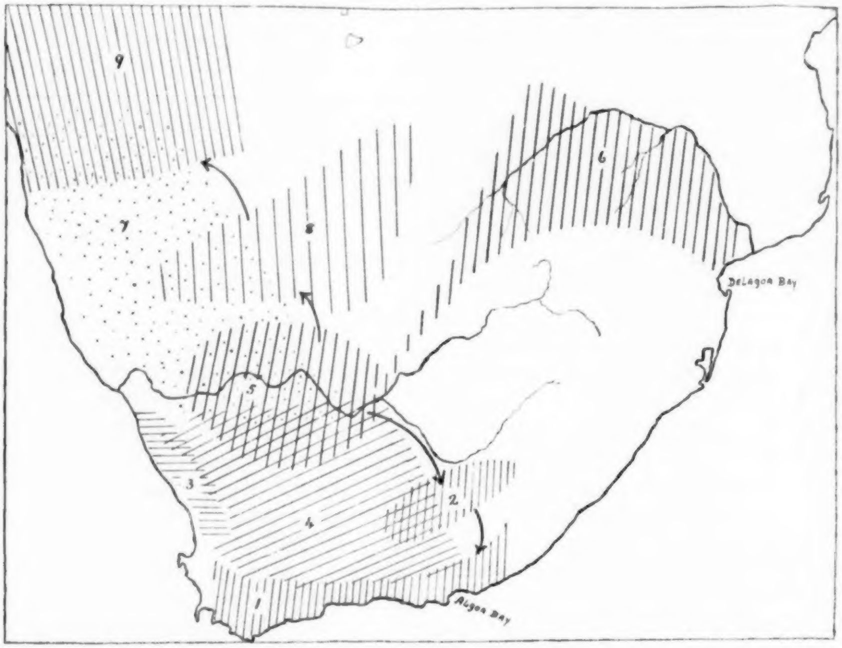
Parabuthus.—This genus occurs almost throughout Africa and Arabia. It seems to be absent from forest regions, at any rate in the south, no records being known to me from Pondoland or Natal. Morphologically, it greatly resembles *Buthus*, except in the absence of keels on the carapace and tergites. With one solitary exception, the species of this genus have a peculiarity in the upper surfaces of the first two caudal segments, which are modified in connection with the stridulatory function, and no such modification is found in any other genus. The exception is found in *B. granulatus*, a species ranging from the Cape to Namaqualand and the Kalahari: this species is quite like a normal Buthid in the characters of the first two caudal segments, and to this extent must certainly be regarded as the most primitive member of the genus. It is also primitive, apparently, in the absence of a lobe at the base of the pectines in females, a character otherwise found throughout the genus.

On the other hand, it cannot be said that the most northern species are highly specialised: and neither is there great differentiation in the north, all the forms found in N.E. Africa and Arabia being referable to one species, *P. liosoma*.

In this genus, the principal centres of specialisation are found in Southern Africa. So far as the stridulatory mechanism is concerned, the most specialised forms are *P. mosambicensis* Ptrs. and its immediate allies, which are known from Loangwa and Tette, P.E.A., and from the northern Transvaal. Here, the stridulatory area of the second caudal segment is confined to a narrow channel, and composed largely of transverse ridges some of which stretch quite across the area: similar ridges occur also on the first caudal segment, and even on the last tergite. Thence, a series of gradational forms can be traced in respect to this character: the first member is *flavidus*, ranging from Kimberley through Bechuanaland to Bulawayo, a form rather like *mosambicensis*, but with no strong ridges on the last tergite: then come *P. stridulus* from Luderitzbucht, and the several varieties of *laevifrons*. One of the latter, *concolor*, from Keetmanshoop, has the stridulatory ridges of caudal segment II rather less strongly developed, and those of I merely granular; the most southern form, *australis*, found south of the Orange River, is quite devoid of well-developed ridges on both segments; whilst the third form, *militum* from Aus, is more or less intermediate between *concolor* and *australis*. The aforementioned *P. stridulus* should perhaps be regarded as the most specialised form of *laevifrons*, having well-developed stridulatory ridges on caudal segments I and II, but those on I are very fine and numerous. In this group of species, no northern representative

are known to me except *scobinifer* from N.W. Rhodesia, which is much simpler than *mosambicensis* or *flavidus* in its stridulatory characters.

Another group of specialised forms is that including *villosus* of S.W. Africa and Great Bushmanland, *schlechteri* of Great Namaqualand and Bushmanland, and *transvaalicus* of the Transvaal and Bechuanaland Protectorate.



Distribution of *villosus-planicauda* group of the genus *Parabuthus*:—1, *planicauda*; 2, *planicauda* var. *frenchi*; 3, *calvus*; 4, *capensis*; 5, *schlechteri*; 6, *transvaalicus*; 7, *villosus*; 8, *raudus*; 9, *kraepelini*. The arrows indicate possible trend of migration. [A high degree of accuracy is not claimed for this map, as the distribution of several species, especially *raudus*, is only imperfectly worked out.]

The most conspicuous character of these species is the accessory dorsal crest of caudal segment V, which is composed of sharply pointed tubercles. The two species first mentioned are also specialised in the restriction of the stridulatory area on caudal segment II to an isolated depression on the upper surface of that segment, whereas in *transvaalicus* the area is continuous along the upper surface. From *villosus* and *schlechteri*, gradational series may be traced northwards as well as southwards. Of the southern forms, the most primitive is *planicauda*, widely distributed in the coastal regions

of the Cape. It has the accessory crest of caudal segment V very indistinct, and the stridulatory area of caudal segment II is continuous. Closely related thereto is *P. planicauda frenchi*, found in the districts of Graaf Reinet, Middelburg, and Burghersdorp, which differs from typical *planicauda* chiefly in that the stridulatory area of caudal segment II is confined to a rather deep oval depression, extending over a little more than half the length of the dorsal surface. Of the northern forms belonging to this subcontinent, the most primitive seems to be *kraepelini*, known from Swakopmund, Windhuk, and Ovamboland. This corresponds with the southern *planicauda* in the above-mentioned characters, differing therefrom in certain minor respects. Occupying an area between this and the centre of specialisation is *raudus*, known from the Kalahari, and from Gibeon in Great Namaqualand, a species resembling *planicauda frenchi* in the characters of the stridulatory area and accessory dorsal crest of the fifth caudal segment. To the same group belong two other Cape species, viz. *P. capensis*, very common in the central and western districts of the Cape Province, and *P. calvus*, known only from the western districts of the Cape : these are both considerably modified in certain characters, but are evidently members of the *planicauda* stock, resembling that species in the character of the stridulatory area.

Only one other species remains to be mentioned, viz. *brevimanus*, a very peculiar form found in S.W. Africa and Great Bushmanland. One of its characters, unique in the genus, but greatly resembling a character found also in the genus *Karasbergia*, which occupies the same region, is the U-shaped crest on the inferior surface of the caudal segments II and III, accompanied by atrophy of some of the normal crests of the tail. These seem best explained as independently evolved in the two genera, being probably adaptation characters of local origin. But for this specialisation, *brevimanus* seems not very different from other Cape species.

On such data, this genus provides considerable evidence in favour of South African centres of evolution. Nevertheless, the evidence does not warrant the assumption that the genus originated in South Africa, seeing that the most primitive of all its species is South African, and that there are no positive characters to distinguish it from *Buthus*.

Pseudolychas Krpln.—This genus is peculiar to South Africa, and is related to *Odonturus* of East Africa and Madagascar, *Babycurus* of East Africa, and *Lychas* of tropical Africa, India, and Australia. The two species referred thereto were originally described as species of *Lychas*, and indeed the distinguishing characters of the genus are not very marked. There is, however, one important character in which the two species are unquestionably simpler than any *Lychas*, viz. in the weak development of the tubercle beneath the aculeus. This simplicity is more marked in

ochraceus, the species found at Redhouse, near Port Elizabeth (and recorded also from the Free State), the other species *pegleri*, extending from Umtata to Zululand and the Transvaal, being nearer to a typical *Lychas* in that respect. They also differ from the African species of *Lychas* in having fewer pectinal teeth, and again *ochraceus* seems more primitive, having only 10 such teeth, against 11–12 in *pegleri* of Umtata and 12–14 in the Zululand form of that species: the tropical African species of *Lychas* have 14–16 and 15–16 teeth, and *Odonturus* even 21–27. On the other hand, we may note that the granularity of the sternites is more extensive in *ochraceus* than in *pegleri*, and that in both species the tergites are definitely tricarinate, which is not the case in any of the East African species of *Lychas*. But, with these possible exceptions, I can find nothing in the characters of either species that necessarily implies an evolution in Southern Africa. On the carination of the tergites, a southern origin is not incontestable, as certain Indian species of *Lychas* are thus endowed. However this may be, restricting our attention to characters of more than specific value, it is certain that *Pseudolychas* is a comparatively primitive representative of the group of East African genera including *Babycurus*, *Odonturus*, and *Lychas*.

Genus *Uroplectes*.—This is distinguished from the genera previously mentioned by the absence of teeth on the lower margin of the immovable finger of the chelicera, and is somewhat composite, for its several groups are distinguished by digital characters of great constancy and perhaps of generic importance. The most primitive section is that including *U. carinatus*, *planimanus*, etc., a group which has the digital dentition very like that of *Parabuthus* and *Buthus*, and all the normal caudal crests are present. This group seems to be the most primitive portion of the *Buthus-Parabuthus* stock. It is confined to South Africa, and is mainly western. The most specialised member is *planimanus*, which is widespread in the tropical and sub-tropical parts of our region. The simplest member in respect to the number of pectinal teeth, the 10 keels on caudal segment IV (but the middle lateral crest is very weak), and probably also in the colour pattern, is *U. variegatus* Koch., known only from the Cape Peninsula. Yet, even this species has minor specialisations, such as a tubercle under the base of the aculeus, and an enlarged basal pectinal tooth in the female, the former character being absent from other members of the group. The area between *planimanus* and *variegatus* is occupied by the several forms of *carinatus*, of which in turn the simplest members are in the south.

Another distinct section is that of *formosus-lineatus*, which extends from Zululand and Eastern Transvaal along the eastern and southern districts to the Cape Peninsula. It is noteworthy as occurring within forests, although not confined thereto. The whole group is somewhat specialised

in the digital dentition and in the reduction of the caudal crests—the inferior median keel of caudal segment V being lacking in all, and various other crests in the more advanced species ; also, there is a distinct tubercle below the aculeus. In this section, the most primitive forms are those found in and near the Cape Peninsula : thence to Zululand and Eastern Transvaal there is a gradational series of forms.

A third section is that of *triangulifer-flavoviridis*, also more or less specialised in the digital dentition, and lacking the inferomedian crest on caudal segment V. It occupies the central districts of South Africa. Here, too, the northernmost form *flavoviridis* of S. Rhodesia is the most specialised in the reduction of the caudal crests ; also the Cape form of *triangulifer* is more primitive than the Transvaal forms of that species ; yet, on the whole, the most primitive member of the whole group seems to be *olivaceus* of the Zoutpansberg district, a fact which is interpreted as implying a secondary specialisation in its southern ally *triangulifer*.

A fourth section is that including *vittatus*, *chubbi*, and various tropical forms. These species are all much specialised, having more or less completely lost the caudal crests. This is the northernmost section of the genus, extending as far as Somaliland on the east side and to Kamerun on the west : southwards, it extends to the Transvaal and Bechuanaland Protectorate.

From the above brief sketch, it will be seen that, taking the genus as a whole, the most primitive species are all in the south ; and it may be added that in two of the groups, at least, a well-marked series of gradational forms can be recognised in passing from north to south or from north-east to south-west.

Karasbergia.—This genus, having a more or less pentagonal sternum, is clearly primitive amongst Buthidae, and another primitive character, which it shares with *Uroplectes*, is the absence of teeth from the inferior margin of the immovable finger of the chelicera : other characters that may belong to the same category are the digital dentition, the few pectinal teeth with the basal one unmodified, and the absence of keels on the carapace and of lateral keels on the tergites. Yet, the tail characters must certainly be regarded as much specialised, closely resembling those found in *Parabuthus brevimanus*, occurring in the same locality, but having no direct relationship with *Karasbergia*.

Only one species is known, and the range seems very limited, extending from the Orange River to the Great Karas Mountains in Great Namaqualand.

With regard to the number of pectinal teeth (11–13), we may note that this is nearly the same as in the southern species of three other Buthid genera, only remotely related to *Karasbergia*, *Buthus conspersus* having 14, *Pseudolychas ochraceus* having 10, and *Uroplectes variegatus* 15.

Family SCORPIONIDAE.

Subfamily Scorpioninae.

Opisthophthalmus.—This genus occurs throughout South Africa, being very abundant everywhere, except in forests and on high mountains. It extends northwards to the Cunene River on the west, and to the equatorial region on the east side, but its greatest differentiation is south of the tropic of Capricorn. There is a closely related genus, *Scorpio*, in North Africa, the intervening region being occupied by a third genus, ***Pandinus***, which includes the giants of the family.

Opisthophthalmus is a very protean genus. Each of the thirty-two known species has its own limited range of distribution, the closely allied forms being separated from each other, either geographically or topographically. Assuming that the genus originally had all the simpler characters now common to two or all of the well-marked groups, Scorpioninae, Ischnurinae, and Buthidae, then, the species which has retained the greatest number of primitive features in its structure is *carinatus* of the Kalahari and Bushmanland: it has the median eyes placed not far behind the centre of the carapace, there is a Y-shaped groove in the region of the frons, the sternites are all smooth, and the hands are more or less alike in both sexes, with well-developed finger-keels. Yet, that *carinatus* cannot be wholly primitive, seems clearly indicated by the large number of pectinal teeth (15–20 in female, and 24–32 in male), and especially by the deep median notch on the anterior border of the carapace. Another species with well-marked primitive characters is *O. capensis*, confined to the south-western districts of the Cape. This species has the Y-shaped groove on the carapace, as before, but the median notch is less pronounced: the hands have well-developed finger-keels, and there are only 15 pectinal teeth in the adult male, or fewer. But, on the other hand, *capensis* has granulated sternites in the male, and the median eyes are situated considerably behind the middle of the carapace, which are certainly not primitive characters.

In some respects, the most specialised species of the genus are several forms occupying karroid areas north and south of the Orange River, *O. karrooensis* and allies. These have the median eyes placed far back on the carapace, there is no Y-shaped groove on the frons, the sternites are strongly granulated in males, the hands are very different in the two sexes, being greatly elongated in the adult male, there is a well-developed postero-dorsal crest on the brachium, marking off the upper and posterior surfaces, and the superior processes of the tarsi are very short: yet, here too are some primitive characters such as the well-developed finger-keel, and perhaps also the moderately slender tail with strong caudal crests. Another advanced species, *glabrifrons*, is less specialised than *karrooensis* in the fewer

pectinal teeth, the shorter hands of adult males, and the less granulated sternites, but is apparently more specialised in the reduction of the finger-keel, the weakness of the supero-anterior crest of the brachium, and the stoutness of the tail.

Without citing further instances, it may be stated as a general rule that the various characters of a species are not all at the same stage of specialisation.

Glabrifrons-latimanus Group.

A very outstanding fact in the distribution of the species of *Opisthophthalmus* is that based on the presence or absence of the Y-shaped groove on the frons, a primitive character not found in the other genera of this subfamily, or only weakly developed * : on this character, specialised species occur throughout the eastern half of the subcontinent from Lake Nyassa southwards as far as False Bay on the southern coast : but the primitive species are all located in the western districts of the Cape and in the Kalahari. The eastern species constitute the *glabrifrons-latimanus* group, which has ts most southern member in *macer*, a coastal species ranging from Port Elizabeth to False Bay. Now *macer* is clearly a comparatively primitive member of its group, whilst the more eastern and northern forms, such as *latimanus* and *glabrifrons*, are more specialised : this, on the characters of the hands and of the sternites, seems incontestable, and I can find no evidence pointing to a contrary conclusion. A similar fact emerges from a study of another series of closely related forms, viz. *glabrifrons* of the Transvaal, *natalensis* of Natal, and *keilandsi* of the Kei River : these are arranged in order of complexity, the most primitive in the south.

The gradation of complexity is not, however, so simply arranged throughout the group, for some forms such as *austeroides* appear to have achieved secondary specialisation in the south. This variety, which occurs in the Middelburg and Herschel districts of the Cape, is in most respects a primitive member of the *glabrifrons-latimanus* group, but the palpal segments are peculiarly elongated. It connects *latimanus* with a form which, though

* This character is present only in those species which have a continuous and sharply defined median groove on the carapace from the eyes to the anterior margin. The groove, and its anterior bifurcation, is most pronounced in *carinatus* : the former is weak and discontinuous, and the latter quite absent, in *wahlbergi* and *glabrifrons*. This groove is a very widespread character in the family, occurring throughout the Ischnurinae and Urodacinae : the anterior bifurcation also is found in all Ischnurine genera. Yet, in very young specimens the groove is always weak and its anterior bifurcation lacking : no phylogenetic importance should be attached to this fact, inasmuch as other juvenile characters are clearly not ancestral—for example, the newly hatched young of *Opisthophthalmus* have the caudal segments quite devoid of crests. The permanently juvenile condition of *glabrifrons* is, therefore, best regarded as a loss-mutation.

primitive in most characters, seems even more specialised than *austeroides* in those of the palp, viz. *austerus*, a widespread species in the Karroo.

This species has very long slender hands in the adult male and the humerus is unusually long. Passing westwards into Clanwilliam and Namaqualand, *austerus* again gives place to *peringueyi*. Now these two species have a close resemblance to each other, differing chiefly in that *peringueyi* has a

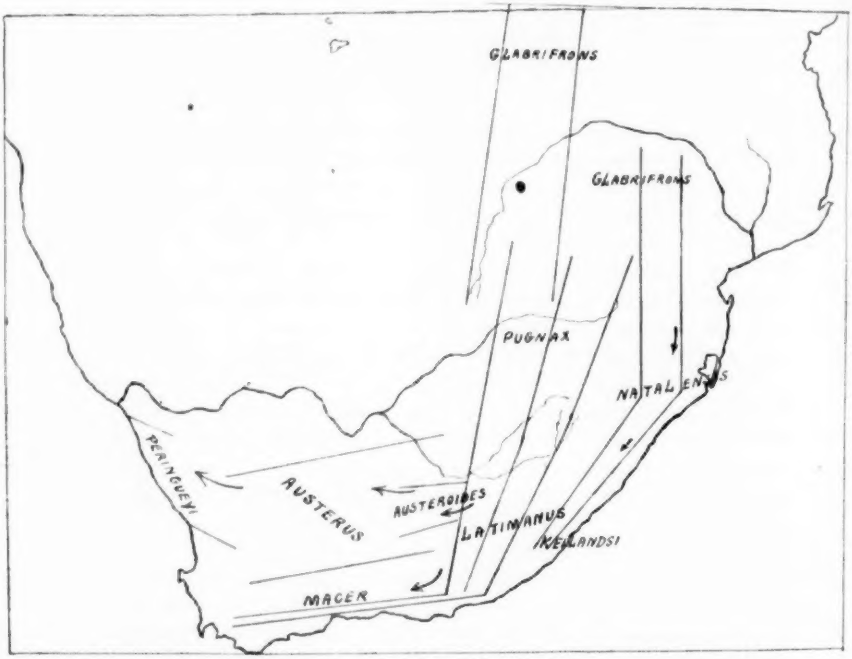


Diagram illustrating distribution of the species of the *glabrifrons* group of the genus *Opisthophthalmus*. The probable trend of past migrations is indicated by arrows.

well-developed Y-shaped groove on the frons, which is lacking or but feebly indicated in *austerus*: there are also minor differences, but it seems extremely probable that when material from intervening localities is found, it will become very difficult to draw a hard-and-fast line between the two species. Thus, ignoring for the present the elongated hands of the several karroid forms just mentioned—a character restricted to the adult males,—one cannot fail to recognise here a morphologically graded series. Starting from *peringueyi* of the western Cape Province—which has a Y-shaped groove on the frons, a well-developed finger-keel, smooth sternites, a

moderately slender tail with superior crests terminating in enlarged teeth—we pass first into *austerus* of the central districts of the Cape, then *austeroides* of the Middelburg and Herschel districts, *latimanus* of the eastern districts of the Cape, and finally end in *glabrifrons* of Rhodesia—which has no trace of a Y-shaped groove on the frons, finger-keel broken up or ill-developed, sternites and first caudal segment of male granulated inferiorly, and the stout tail without enlarged teeth on the superior crests.

It is not claimed that in every respect a northern form is more specialised than its southern or western allies, nor that the gradational characters are the only ones separating the species from each other. Allowance may have to be made for a limited amount of local variation. Yet, so far as I know, there is not in this group a single character the variations of which form a continuous gradational series in a direction reverse to that above mentioned, except to a limited extent the character of palpal elongation in the adult male.

Capensis-granifrons Group.

This group of species, characteristic of the western districts of the Cape, has its smallest and most primitive form in *O. capensis* of the Cape Peninsula. Most of the species have a well-developed Y-shaped groove on the frons, but one of them, *crassimanus*, is usually without that groove. Between *capensis* and *crassimanus* are all grades of intermediates in various characters. The latter, found in Bushmanland and districts bordering the Orange River, has large rounded hands with finger-keels broken up into granules, all the sternites of the male are granulated, the superior processes of the tarsi are very short, and the Y-shaped groove on the frons is obsolete: south and south-east of it is *pictus*, ranging from Kimberley to Port Elizabeth, a form with well-developed Y-shaped groove, finger-keels only broken to slight extent, sternities all very coarsely granulated, and superior processes of tarsi not so short as in *crassimanus*: somewhat less specialised is *granifrons* of Namaqualand, C.P., in which the first sternite is not granulated, superior processes of tarsi of moderate length, but the finger-keel is still broken up into granules: lastly, *capensis* has a strong continuous finger-keel, the superior process of the tarsus is as long as the lateral lobes, and the first three sternites of the male are not granulated.

So far as is known there is no representative of this group north of the Orange River.

Karrooensis Group.

The most specialised forms of this group are *karrooensis*, widespread in the central karroid regions of the Cape, *longicauda* from Great Bushmanland up to the Orange River, and *gigas* from Great Namaqualand and Bush-

manland. They are each characterised by the possession of very long slender hands in the adult male, and the carapace and segments of the palps are somewhat depressed: the carapace is coarsely granulated at the sides, but lacks the Y-shaped groove, superior crests of the tail with enlarged terminal teeth, superior processes of the tarsi unusually short, finger-keel well developed, the upper surface of the brachium with well-developed posterior crest—the latter, a most peculiar feature recalling that of *Opisthacanthus* and *Hadogenes*. Of these three, *longicauda* is most specialised in that the sternites are all densely and coarsely granular, whereas in *karrooensis* the first or first two sternites are devoid of granules: *gigas*, again, has the sternites smooth in specimens found south of the Orange River, but with very minute scattered granules north of that river. Passing far southwards into the districts of Worcester and Caledon, we find a primitive form of *karrooensis* in *O. fossor*. This has just a trace of the Y-shaped groove on the carapace, hands of more normal shape, palps not so elongated but still possessing a posterior crest on the brachium; only the last sternite is granulated, and the superior processes of the tarsi are of moderate length. The species *chaperi* of Worcester and Robertson is another primitive form related to *fossor*; and *O. pattisoni* of the Clanwilliam division is evidently a primitive member of this group, with the sternites practically smooth, but the hands are longer and narrower than in *fossor*.

Passing westwards, on the other hand, *karrooensis* gives place to another long-fingered species, viz. *pallidipes*, which inhabits a strip of country along the western Cape coast. This species has a well-developed Y-shaped groove on the frons, the sternites are quite smooth, and the posterior crest of the brachium is not nearly so strong as in *karrooensis*: otherwise, there is a close general resemblance between the two species. Thus, we see that in this group also the most primitive forms are found in the south and western districts.

On the eastern side is a specialised relative of *karrooensis* in the Albany and Somerset East districts along the Fish River valley. This species, *nitidiceps*, also has relationship with *crassimanus*. It has all the sternites of the male thickly granulated, hand very like that of *crassimanus* but the finger-keel only slightly broken up into granules, carapace without coarse granules at the sides, terminal teeth of superior caudal crests not, or only slightly, enlarged. This is evidently a fairly high type belonging to the same stock that produced both *karrooensis* and *crassimanus*.

For our present purpose, it is unnecessary to deal with the characters and distribution of the little-known species that inhabit the Kalahari and the S.W. African Protectorate, species which for the most part are less specialised than those found south of the Orange River. We already have

sufficient data to justify the following preliminary statement: The species of the genus *Opisthophthalmus* fall into several natural groups, each group occupying, sometimes exclusively, a large tract of country: in each group, the most southern or south-western species is on the whole the most primitive, and in every case the northern or eastern forms are comparatively specialised: confining our attention to single characters, a fairly well-defined series of gradational forms is frequently found on passing along a direct line from north to south or from north-east to south-west: further, within the limits of any one group, two or several characters—such as granulation of sternites, development of finger-keel, etc.—may yield approximately the same series of gradational forms, although the variations of these several characters are not very rigidly linked together, and indeed, taking the genus as a whole, no such correlation can be found.

Now, how is this gradational variation to be explained? It seems difficult to connect it with any observable gradation in the environmental conditions. Passing southwards overland from the Zambesi to Mossel Bay, we may certainly detect changes in the various components of the physical environment, but, so far as one can see, there is no environmental variation that is parallel with the variation of the sternites in the *glabrifrons-latimanus* group, or which correspond with the varying characters of the hand in those species. However this may be, when seeking to explain the simplicity of southern forms, we may reject the idea of reversible evolution as highly improbable. We should not assume that the forms of the Southern Cape and south-western districts have merely a secondary simplicity, as a result of cold or other adverse factor. Actually, this simplicity is not by any means confined to those more temperate districts, two of the most generalised genera of the order, viz. *Opisthophthalmus* and *Uroplectes*, extending northwards from the Cape to the tropics, and a third one, *Nanobuthus*, being confined to the neighbourhood of the Red Sea. In most forms of animal life, degeneracy of structure seems to be accompanied by a more or less profound change of habits, but, so far as we know, *Buthus*, *Parabuthus*, and *Uroplectes* are much alike in that respect. Nor does such explanation receive support from the known facts of their post-natal development: species like *macer*, with smooth sternites, do not pass through a granulated stage in the course of their development.

The variation we are now considering, sometimes referred to as orthogenetic, is presumed to have arisen spontaneously at some centre of evolution. The earliest forms, simple and unspecialised, made their way to the south and south-western districts, followed in regular order by the successively formed higher types. It is supposed that these higher types either expelled their primitive predecessors, or at all events replaced them, when the struggle for existence made it impossible for the latter to retain their position.

All the main facts of distribution in the *glabrifrons-latimanus* group could be explained on the assumption of a former centre of dispersal in the Limpopo region. Thence one primitive form, *macer*, migrated to the Southern Cape coast, followed closely by *latimanus*. A later stock passed down the eastern side of the Drakensberg, reaching the Kei River, followed by *natalensis*, now in Natal, and then by the Transvaal variety of *glabrifrons*. The earliest form of the whole group made its way to the western districts of the Cape, being now represented by *peringueyi* : then followed a somewhat higher type, *austerus*, now confined to karroo districts. These two essentially primitive species bear witness to some independent evolution in the south, chiefly in respect to the peculiar characters of their palps, which possibly are related to local environmental conditions.

It is a significant fact that several karroo-dwelling species which show marked independent variation, have a different habit from that prevailing throughout the rest of the genus. Nearly all species of *Opisthophthalmus* occupy deep burrows in the ground, but those like *karrooensis*, characterised by long slender hands in the adult male and somewhat depressed carapace and palp, do not burrow but hide under rocks and stones. Now, in the other subfamily, Ischnurinae, there is one genus, *Hadogenes*, which is characteristically rupicolous, being practically confined to stony kopjes, living under large stones and in narrow rock-crevices. This genus is exceptionally depressed in the carapace and palps, the upper surface of the brachium being quite broad and flat, bounded behind and in front by strong keels. Here, also, we usually find an extraordinary elongation of the tail in the adult male, which may be compared with the elongation of the palps in *austerus* and *karrooensis*. Another Ischnurine genus, *Opisthacanthus*, lives under the bark of dead trees, or under stones in bush and on dry kopjes : this also is more or less flattened in body and palps. But *Cheloctonus*, the third genus of the same subfamily, is not flattened in most of its species, and it is interesting to find that the Cape species, *crassimanus*, is a burrower on the grass-veld of Butterworth commonage (W. Tooke).

It seems quite clear that flattened carapace and palps, and possibly even elongation of palps as in *karrooensis*, are adaptation characters directly connected with a rupicolous habitat. Yet, adaptation characters, however complete, are not necessarily of local origin : such characters, like all others, may presumably travel long distances along a route of suitable habitat. In this instance, however, the evidence is in favour of local evolution, inasmuch as the modification has occurred in the midst of what appears to be a gradational series, beginning with *chaperi*, *fossor*, and *pattisoni*, and terminating in *nitidiceps*. We may note further, that a comparable change has taken place, apparently quite independently, in another group of the

genus, the *glabrifrons-latimanus* group: but, in neither case are there any species with similar modifications in more northern parts of our region, although the *glabrifrons* group extends even beyond the Zambesi.

How the adaptation to the rupicolous habit came about is merely a matter for conjecture. Those who still believe in the inheritance of acquired characters can assume it to have arisen as a direct consequence of pressure within rock-crevices during the infantile period: this may explain the flattening of the carapace and palps, and even the formation of the posterior brachial crest in *karrooensis*, but scarcely affords a satisfactory explanation of the lengthening of the palps in the adult males. Others will think it sufficient to regard these two variations—a general flattening, and excessive elongation—as purely spontaneous in origin, and likely to arise anywhere, but only capable of surviving in a rocky environment. That creatures thus endowed can occupy a habitat which is inaccessible to scorpions of normal build is certain enough: and it seems not improbable that such creatures could not compete successfully with normal types in a more normal habitat.

Again, from consideration of various positive characters, such as the peculiar stridulatory organs, the position of the median eyes, the granularity of the sternites, and the elongation of the hands in certain species, we seem compelled to recognise that much evolution has occurred within this sub-continent. A study of the variations in the number of pectinal teeth throughout the family indicates this as a region of quite unusual activity. The highest number of pectinal teeth found in the whole family is met with in such species as *Opisthophthalmus carinatus* (24–32 in male), *pallidipes* and *karrooensis* (25–31 in male): whereas, the oriental genus *Palamnaeus* only rarely has so many as 20 such teeth, and much the same may be said of *Pandinus*, the dominant genus of tropical Africa, whilst *Scorpio* of North Africa has not more than 14, and *O. capensis* of the Cape Town neighbourhood rarely if ever has more than 15 pectinal teeth in the adult male.

But, although in some individual characters certain species of *Opisthophthalmus* are undoubtedly the most specialised of all the Scorpionidae, yet, just as certainly the genus includes the most primitive species of the family, and, strangely enough, one of the most primitive species (*carinatus*) exhibits extreme specialisation in the pectinal character. In all these instances of specialisation, the character concerned is very variable, being rarely even of specific importance: for instance, the stridulatory lamellae on the chelicerae may be present in fully developed condition, or completely absent in different individuals of the same species: similarly, the position of the median eyes varies appreciably within the limits of a species. When estimating the status of the genus we have therefore to ignore these in-

constant characters, recognising the fact that the unmodified species of *Opisthophthalmus* constitute the most primitive section of the whole family, being placed below *Scorpio* chiefly on the evidence of the Y-shaped groove of the frons.

The relationships of the genus are plainly with *Scorpio* of N. Africa,

The distribution of two pairs of related genera—***Opisthophthalmus*** and ***Scorpio*** represented by lines in south and north, respectively, ***Pandinus*** and ***Palamnaeus*** represented by dots, the former African and the latter Asiatic. No member of this subfamily occurs in Madagascar.

rather than with the tropical African genus *Pandinus*, from which it is sharply separated *: so much so, that one species (*boehmi*, from Lake Tanganyika) has been variously referred by good authorities to both *Opisthophthalmus* and *Scorpio*. *Pandinus* in several important characters (chelicerae, *e.g.*) is definitely more specialised than *Opisthophthalmus*, and

* A somewhat similar case is known amongst the Elapid snakes: *Walterinnesia*, found on the high desert a few miles east of Cairo, is related to the South African *Sepedon*, whilst the greater portion of the African continent is occupied by the dominant genus *Naia*.

is closely related to the oriental genus *Palamnaeus*: taking all the facts of morphology and distribution into consideration, it is a reasonable presumption that the development of this genus within the tropical parts of Africa has resulted in the separation of the original Scorpionid stock into two sections—*Opisthophthalmus* in the south, and *Scorpio* in the north. Whether the *Pandinus-Palamnaeus* group had its origin in Africa or in Asia is quite uncertain, but it may be mentioned that in some respects *Pandinus* is the more specialised genus. It is clear that we must not look to the extreme south of Africa as the place of origin or dispersal of the Scorpionid genera, for all the main migration routes have a southern trend. Only a secondary centre of evolution in the south need be assumed to explain the occurrence of specialised species of *Opisthophthalmus* in the karroo.

Subfamily Ischnurinae.

This subfamily is Asiatic, African, and neotropical in distribution, but in Africa is unknown north of the Sahara and is apparently absent from Abyssinia, Somaliland, and Uganda, although one genus occurs in S. Arabia and Socotra. In most respects it is more specialised than the Scorpionini, the chelicerae having a double fang on the movable finger, and the tail having fewer crests.

Cheloctonus.—This genus, only found in the eastern districts of South Africa, especially in the neighbourhood of the Drakensberg range, is clearly the simplest of its subfamily. This is inferred from the dentition of the chelae, which has a general resemblance to that of the Scorpionini, thus differing from all other Ischnurine genera: the latter, moreover, as shown in *Opisthacanthus validus*, pass through a Cheloctonus stage in very young specimens. In this genus also, the digits are not strongly lobate and sinuate at the base, and the brachium has but a mere indication of the anterior prominence. Five distinct species have been described, with several subspecies which connect them together more or less completely. Thus, *C. jonesi*, ranging over the northern and eastern Transvaal and Zululand, has a form (*sculpturatus*) in the Rustenburg district, and a very similar one in the Ermelo district, which connects it with *anthracinus* of Basutoland and Griqualand East, and this again is very closely related to *crassimanus* of the Transkei and Kingwilliamstown. In this instance, it is evident that *jonesi*, the northernmost form, is also the most specialised, having most pectinal teeth, and the humerus lacking a supero-anterior crest. Perhaps the most primitive form known is *glaber*, which occurs at Whittlesea: it has the upper surface of the hand comparatively flat, and a well-marked supero-anterior crest on the humerus is present. This species has a more specialised relative in the north, for *C. intermedius* from Lydenburg district

has much in common therewith, but the vesicle has a double row of granules inferiorly, a character not found in any other species. The genus *Cheloctonus* is noteworthy in having a small number of pectinal teeth, usually 4–7, but in *jonesi* sometimes 8. On comparison with other genera of the same subfamily, I believe that a small number of teeth is a primitive character.

Opisthacanthus.—This genus enjoys a wide distribution in forest regions throughout south, west, and east Africa; there are also two species in Madagascar, and a single species in the northern part of the neotropical region. Morphologically, the highest species in Africa is *lecomtei*, from equatorial West Africa (Kamerun to Gabun). This and *africanus*, which is also West African, are distinguished from all the other African species in that the tail is smooth and polished with no inferior keels on the first three segments. The greatest number of pectinal teeth is found in *lecomtei* (9–13), whilst *asper* and *fischeri*, the East African species, *laevipes* from Barberton, and *chrysopus* from Zululand, each have 8–10 pectinal teeth, at any rate in the males: but all the species from the Cape Province and from the Drakensberg have only 5–7 such teeth. Amongst the latter species, *validus* has the most extensive distribution, ranging from the neighbourhood of Grahamstown throughout the Eastern Province into Natal and over the Drakensberg region as far north as the Lydenburg district and possibly further.

Several geographical forms of *validus* are distinguishable, of which the most specialised are *transvaalicus*, which is the most northern, and *fulvipes* of Basutoland: in these forms, the hand has a secondary keel along the inner margin of the upper surface and the vesicle of the male has four rows of granules inferiorly. On the other hand, *albanicus* of Grahamstown and *typicus* of Natal have no such keel on the inner boundary of the upper surface of the hand, and the vesicle is without granular rows inferiorly, or with weak granulations only. The Swaziland form again is like that of Natal, but has well-developed rows of granules under the vesicle.

Besides the above-mentioned species, there remains for consideration only the three confined to the western half of the Cape Province. These closely related forms are probably primitive in most respects, but they show some specialisation: in *capensis*, for instance, the surfaces of the body generally are granulated, and the vesicle has two well-developed rows of granules on each side inferiorly.

The relationship of the single neotropical species (*O. elatus*) to those of Africa has not been so thoroughly investigated as the interest of the problem would warrant, owing to my lack of material from West Africa. In several respects, *elatus* seems to be more specialised than the South African species: the anterior projection of the brachium is more strongly developed, and the

tail is less definitely keeled. The Malagasy species are also more advanced than those of South Africa in the brachial character, resembling *Hadogenes* in the development of the anterior prominence. The occurrence of the same Ischnurine genera in South Africa and Madagascar, and the absence of Scorpionine genera from that island, may indicate the greater antiquity of Ischnurines in the Ethiopian region: but this interpretation is unsatisfactory owing to the possibility of oversea transport by *Opisthacanthus* on floating timber.

Hadogenes.—This genus occurs only in Southern Africa and Madagascar, being found under rocks and large stones, especially on kopjes. It extends northwards as far as the Feira district, and on the west side to Congo territory: southwards, it is absent apparently from the southern coast region between Port Elizabeth and Cape Town. It is related to *Opisthacanthus* but is definitely more advanced, and most of the species are specialised in accordance with its rupicolous habit, the body and palps being much flattened and the tail laterally compressed. The species of *Hadogenes* have not been well collected, and the distribution is only very imperfectly known. In my account of this genus, the species were classified tentatively in three groups according to the form of the anterior margin of the carapace. The first group, with straight anterior margin, must certainly be regarded as specialised, for no such character occurs in any of the species of *Opisthacanthus* or *Cheloctonus*, nor in any other genus of the whole family. In this group is found *troglodytes* and *granulatus*, which are the giants of the genus, and apparently also *paucidens*, the Congo species. A Zoutpansberg specimen of *troglodytes* has the record for length amongst the scorpions of the whole world, and the same species has also an unusually large number of pectinal teeth, a maximum of thirty being recorded in the adult male. Now these two species are both northern, *troglodytes* ranging from Bechuanaland Protectorate and the Zoutpansberg district up to the Zambesi, and *granulatus* being known from Southern Rhodesia. There is a small southern form of *troglodytes* at Pretoria, viz. *H. gunningi*: it has fewer pectinal teeth, and the anterior margin of the carapace is lightly emarginate.

On the character above mentioned, the most primitive group of the genus is that of *trichiurus*. The various forms of this species range from Estcourt and Weenen in Natal into the Eastern Province as far south and west as Alicedale, and there is a form in the eastern karroo known from Cradock, Graaff Reinet, and Rosmead. Of these forms, the most primitive seem to be those occurring near Grahamstown (*whitei* and *parvus*): they have slightly fewer pectinal teeth (17 in *whitei*) than in the Transkei (19–23) and Natal (18–20) varieties, the first caudal segment is less compressed, and the hand in *parvus* is less elongated, thus approaching the *Opisthacanthus* condition: but, as in all the known forms of *trichiurus*, the caudal

characters are considerably specialised. Nearly related to *trichiurus*, but with the anterior margin of the carapace only lightly incised, are the several forms of *gracilis*. The typical form of *gracilis*, found at Pretoria, is the most specialised of all the *trichiurus-gracilis* association: it has the caudal segments of the adult male excessively elongated. Another form of *gracilis* occurs at O'Okiep in Little Namaqualand, which considerably resembles the eastern karroo forms of *trichiurus*, but the carapace is only lightly emarginate in front, and the second and third caudal segments have no spiniform posterior teeth on their superior crests. Only one other species has been recorded from the Cape Province, but the adult male is still unknown, and thus the position in the system is somewhat uncertain. This species, *minor*, from the mountains in the Calvinia and Clanwilliam districts, is very probably a primitive one, more so than the O'Okiep form of *gracilis*, for Dr. Purcell describes the carapace as "broadly and moderately emarginate in front."

There remains for consideration two northern species which, unlike the northern forms previously considered, are on the whole primitive. One of them, *bicolor*, of the Zoutpansberg and Lydenburg districts, has the anterior border of the carapace moderately incised, and the tail of the male not very different from that of the female: the latter character is thus less specialised than in any known form of *trichiurus*. Its palpal characters, on the other hand, are not primitive. The other northern form is *tityrus*, recorded from the neighbourhood of Windhoek and from Great Namaqualand. This species, unknown to me except from the descriptions, is stated to have only 13–15 pectinal teeth in the male, and 9–10 in the female, and the tail of the adult male is apparently not much elongated: but, here again is some specialisation, inasmuch as the anterior border of the carapace is straight or almost so.

We see therefore that in the genus *Hadogenes* there is a centre of specialisation in the Transvaal and South Rhodesia: away from that centre, southwards, westwards, or eastwards, the specialised characters disappear to some extent, and near the periphery of the continent more primitive forms preponderate. It is possible that the genus evolved its specialised forms in the subcontinent. The occurrence of primitive forms in the North-Eastern Transvaal, and in Damaraland, is readily understood on that hypothesis. Thus one might explain the otherwise remarkable fact that the Ischnurine species occurring in Central Africa, north of the range of *Hadogenes*, do not possess greatly elongated tails as in many forms of that genus.

Yet, the genus *Hemiscorpius*, of Erythraea, South Arabia, and Socotra, has considerable resemblance to *Hadogenes*, having the tail of the adult male greatly elongated, and even the vesicle much longer than that of the female. Its most distinctive character is the occurrence of a single inferior

median keel on all the caudal segments instead of on the fifth only. This seems to be the culmination of an evolutionary process that commenced in *Hadogenes*. In this respect, *Hemiscorpius* is certainly the most specialised member of the Ischnurine genera, and herein is suggestion of a northern origin for the *Hadogenes* stock.

I have not been able to make an independent investigation of the relationship of *Hadogenes* to the various Asiatic genera. But, we may note that in the very large anterior brachial prominence, *Hadogenes* is more advanced than the African species of *Opisthacanthus*, and in this respect agrees better with several Asiatic genera.

The genus *Iomachus*, which occurs in East Africa and in India, is also specialised in its caudal characters, but in another direction, none of the segments of the tail being keeled.

Summary.

1. The South African scorpion fauna is composed as follows :—

Family Scorpionidae.—Opisthophthalmus, the only South African genus of the Scorpionini, is a very primitive one, as evidenced by the characters of the chelicerae, of the sternum, and of the lung-books. Such a combination of primitive characters is unknown elsewhere except in its near allies the North African genus *Scorpio*, and amongst the Urodacini of Australia (possibly also the Bothriuridae of Australia and South America): and indeed one section of the genus *Opisthophthalmus* appears to be more primitive than the northern *Scorpio*. The South African members of the subfamily Ischnurini are also primitive on the whole. *Cheloctonus* must even rank as the lowest member of the subfamily: the South African species of *Opisthacanthus* are all generalised, and *Hadogenes*, though decidedly more advanced, is apparently not so much so as the Arabian *Hemiscorpius*.

Family Buthidae.—This advanced family has its three most primitive genera (on the evidence of chelicera characters, and others) in Africa: *Karasbergia*, perhaps the simplest of all, in Namaqualand; *Uroplectes* throughout Southern Africa; and *Nanobuthus* in East Africa. The other South African members of this family belong to genera of wide distribution (or in the case of the species of *Pseudolychas* are closely related to a wide-spread genus, *Lychas*).

2. *Source of the South African Fauna.*—The prevalence of primitive types in South Africa seems definitely against the probability of a South African origin for the families concerned. The whole fauna must have come from elsewhere, presumably the most primitive forms first, and then the advanced ones in regular order.

Considering the great wealth of species in Africa, it seems remarkable that—except on the Mediterranean coast—only two families are represented, neither of them peculiar to this great continent, nor even are there any peculiar subfamilies. In the Indian region, precisely the same families and subfamilies occur, but with them are two additional families, Vejovidae

Illustrating the distribution of the families of scorpions throughout the world. Africa is most ill-endowed of all the warmer regions.

and Chaerilidae, and one subfamily, the Centrurinae (family Buthidae) *: still another family, Chactidae, occurs in Southern Europe, and an additional subfamily of the Scorpionidae occurs in Syria and Arabia, the Diplocentrinae, which are also neotropical.

Assuming that the region of greatest differentiation of a group is its centre of dispersal, then we must certainly look to Eurasia as the immediate source of our scorpion fauna, and also for like reasons as the centre from which

* In certain parts of tropical Africa, a single species (*Isometrus maculatus*) of the oriental subfamily Centrurinae occurs, but this is found on all continents and islands in tropical and subtropical regions, and is presumably a recent immigrant in Africa. Further, according to some authorities, a distinct subfamily, Ananterini, should be recognised for the two Buthid genera Ananteris of South America and Ananteroides of Portuguese Guinea.

Australia and perhaps also the New World received their respective faunas.* This view receives independent support from consideration of the widespread genus *Buthus*: here the most advanced species are all found in Asia or Northern Africa, and the forms occurring south of the Sahara are comparatively primitive.

We must not suppose that the waves of migration in every case entered the continent on its northern side. Against such assumption is the evidence of the Scorpionine genera, which I interpret as follows:—at first the continent was wholly populated by scorpions of the *Opisthophthalmus-Scorpio* type: then *Pandinus* entered on the eastern side, and spreading throughout the central region of Africa divided the original stock into two sections, a northern and a southern one.

3. *Secondary Centres of Evolution in Africa.*—The view that Africa received its scorpion fauna from Eurasia seems almost incontestable. Some of the southern forms are probably very little different from the ancestral stocks comprised amongst the earliest invaders of our region. But in most of the genera we find clear evidence of local evolution. The stridulatory organs of *Parabuthus* and of *Opisthophthalmus*, which are quite peculiar to these African genera, the posteriorly placed eyes, and the granulated sternites of various Opisthophthalmi, and many other specific characters are very probably products of local origin. This we may infer from the fact that such characters reach their maximum development in the southern parts of the continent, and may be quite absent in the allied forms of tropical and Northern Africa. There seems to have been a centre of evolution for the species of *Opisthophthalmus* in the Karroo and South-West Africa; a centre for *Parabuthus* in South-West Africa; and another on the eastern side of the subcontinent near the Zambesi. Certain genera

* I lay stress on this point because, according to certain critics, the method followed throughout the greater part of this paper, involving the classification of related forms into advanced and primitive groups, is one which readily lends itself to a circular argument. That danger must not be overlooked, for no one form can be said to be wholly primitive, nor is it proven that simplicity is truly primitive. Various species of the southern *Opisthophthalmus* are certainly specialised in regard to the posterior position of the eyes, and in the granulation of the sternites: *Pandinus* of Central Africa, and *Palamnaeus* of India are obviously more primitive in these respects. Yet, simply on the evidence of the cheliceral characters, we may assign a more advanced position to the two genera last mentioned: for the cheliceral dentition has the greater systematic value, being constant through a whole series of different forms in young and adult alike, whilst the posterior position of the eyes in *Opisthophthalmus* varies considerably even within the limits of one species; and the granularity of the sternites is also unstable and largely a sexual character. In grading the various forms, positive characters are regarded as important or otherwise in direct proportion to the wideness of their range within the family. In short, the important characters which distinguish an advanced form are so called because of their success.

such as *Parabuthus*, now peculiar to Africa, may also be of African origin, but this is very uncertain: for, *Parabuthus* is chiefly distinguished from *Buthus* by the absence of a character rather than by the possession of some special feature. However this may be, we can find nothing to suggest that any family or even subfamily of scorpions was of South African origin, and the whole African continent does not seem to have contributed much, if anything, to the scorpion fauna of the other continents. Nevertheless, it is quite likely that specialised characters have taken origin in various parts of the continent, some of them unique and striking: but, for some unknown reason, their characters have not been successful in spreading. For instance, the displacement of the eyes in *Opisthophthalmus* is a prominent character which has pervaded many species of that genus, but has spread no further and is peculiarly South African: on the other hand, the acquisition of accessory teeth on the chelicerae amongst the higher Buthids, a character probably of Eurasian origin, has proved most successful, being found in a great variety of forms ranging throughout the warmer parts of the Old World.

4. *Orthogenetic Series.*—The characters used in the discrimination of species and subspecies are generally very variable. Nevertheless, the variations of a character are not distributed erratically. Within a certain limited area, a particular character is tolerably constant; but variations therefrom are regularly arranged in a gradational series along a simple route line, that is, variations *a*, *b*, *c*, and *d*, in ascending order of complexity, occupy positions 1, 2, 3, and 4 on that line. In this way, the subspecies and even related species are more or less linked together: where they are not obviously so, the missing link is probably a mere accident of collecting. These lines of gradational series are best explained as phylogenetic series ranged along former routes of migration, the simplest and oldest forms having migrated furthest from the centre of origin, and the most advanced and recent forms remaining near that centre. This hypothesis furnishes a rational explanation of the fact that the simplest member of the series is generally the most southern one; and it sufficiently explains the fact that in several unrelated genera (*e.g. Opisthophthalmus* and *Uroplectes*) there is considerable coincidence of behaviour along such natural routes as that passing southwards from the Transvaal and Natal through the Eastern Province and along the Southern Cape coast.

Although the genera of scorpions, as now defined, are sharply distinguished from each other, and connecting links seem to be absent, yet the distribution data suggest that they too were formerly arranged in gradational series like the closely related species of the present day. In the Buthidae, South Africa is dominated by *Uroplectes*, one of the most primitive genera: it is the only Buthid genus that can be described as

ubiquitous in the subcontinent. *Parabuthus*, a more advanced genus, is also common in South Africa, except on the high plateau : but this genus extends far more widely into tropical Africa and even to North Africa and Arabia. Finally, the most advanced of all, viz. *Buthus*, is a rarity in South Africa, being altogether unknown in most parts of the country : northwards it ranges throughout Africa and widely also in Asia.

Illustrating the distribution of *Buthus*, *Parabuthus*, and *Uroplectes*, three closely related genera in descending order of complexity. The area enclosed by a black line in the south-west portion of Africa is that of the *carinatus* group of *Uroplectes*, a group apparently representing the most primitive section of the *Buthus* stock.

My friend Dr. J. E. Duerden has in several important papers commented on the meaning of gradational series of species amongst living animals, and has taken exception to their interpretation as phylogenetic series. From the standpoint of mutationists, variation D of the series A, B, C, D may just as easily arise directly from form A as from C. This may be so, but the distribution data do not readily lend themselves to such an explanation.

I would emphasise the fact that gradational series of closely allied species, as known to me amongst South African arachnids and reptiles, never occur together: they are found along geographical routes, arranged in regular order from the highest to the lowest. And, although at the present day members of a gradational series of genera may or may not occur together, there seems much probability from the distribution data that at one time they also arranged themselves in regular succession.

CONTRIBUTIONS TO OUR KNOWLEDGE OF THE FRESHWATER ALGAE OF AFRICA.

5. *On a Deposit of Diatomaceous Earth from Ermelo, Transvaal.**

By F. E. Fritsch
AND
Florence Rich.

(With one Text-figure.)

A year or so ago we received from Miss E. L. Stephens samples of a deposit of diatomaceous earth (kieselguhr) that had been sent to her by Mr. F. N. Searle, a member of a firm of consulting engineers at Johannesburg. The deposit is situated at Farm Bank-plaats, near Ermelo, and is thus described by Mr. Searle in a letter to Miss Stephens : " The deposit consists of a large oval pan about one-third of a mile long and 440 yards wide, and looks more or less like black peat. We dig this out in the same way as they do peat and, after drying it, we calcine it. A remarkable thing is that it possesses sufficient vegetable matter to be self-calcining, and all that is necessary to start it is to put a handful of grass in the kiln sufficient to get it alight, and then it burns itself out automatically.† We have had analysis of up to 97 per cent. of silica from this deposit, but an average is as follows :—

" Silicon dioxide	95·33 per cent.
Magnesia	0·38 ,, ,,
Alumina	1·96 ,, ,,
Oxide of iron	0·82 ,, ,,
Moisture	1·51 ,, ,,

" I have noticed, during the rainy season, deposits of greenish matter lying on top of the water which percolates in streams through this deposit. I understand that this matter contains the live Diatoms."

The samples submitted to us comprised some of the wet-season growth

* From the Botanical Department, East London College, University of London. We are indebted to the Council for Scientific and Industrial Research for a grant enabling the second author to participate in this work.

† No doubt owing to the considerable admixture of filamentous Algae and other vegetable débris.

just mentioned, some of the dried deposit, and some of the calcined material. The dried deposit is grey and of a friable nature, whilst the calcined kieselguhr is of a pure white colour.

The wet-season growth comprises a varied algal flora in which species of *Stigeoclonium*, *Spirogyra*, and *Phormidium* preponderate; there is also some *Oscillatoria*, *Scenedesmus*, and a *Closterium*. Abundant Diatoms are present, and the majority of these are identical with those found in the underlying deposit. The only form found in any quantity in the wet-season growth that was lacking in the kieselguhr was *Synedra ulna*, Ehrenb. var. *aequalis* (Kuetz.), Brun. It is not, however, impossible that the composition of the supernatant growth, and consequently of the underlying deposit, may vary slightly in different parts of the pan. In one of his letters to Miss Stephens, Mr. Searle speaks of having been "informed that the majority of the Diatoms which occur in our kieselguhr are of the *Surirella* type," but such forms were conspicuously absent from all the samples examined by us. It is hardly likely that they would be abundant in one part and completely lacking in another, and the above-mentioned statement is probably erroneous.

Nearly all the Diatoms of the kieselguhr were found with protoplasmic contents in the overlying growth, and there can be no doubt that formation of the deposit is still taking place at the present day, although we are unable to say at what rate. The regular alternation of wet and dry periods, involving as it does the periodic dying off of a great part of the vegetation, may well help to accelerate the rate of formation of the deposit.

The following is a list of the Diatoms that have been recognised in the kieselguhr:—

1. *Epithemia irregularis*, n. sp. (Fig. 1, *B*, *C*).

E. mediocris. Cellula in aspectu valvulari dorso distincte convexa, ventre leviter concava, polis paullo protrusis recurvatis rotundatis; costis in margine perpendiculariter, irregulariter dispositis, approximatis vel remotis in eandem valvam, ca. 1·3–1·6 in 10 μ, punctarum seriebus inter costas 2–7; raphide curváta, e partes duas perpendiculares constante, marginem dorsalem non attingente; intra valvam est septum longitudinale fenestris, cum intervallis inter costas valvae congruentibus, munitis, partitionibus inter fenestras ventre interruptis. Cellula in aspectu cingulato rectangulari lateribus paullo convexis, interdum leviter curvata uno margine recto, septis horizontalibus irregulariter dispositis in oculos rotundos terminatis.

Long. valv. . .	56·0	62·0	68·0	69·0	84·0 μ.
Lat. ,, . .	10·5	12·0	15·0	..	14·0 μ.
Cost. in 10 μ . .	1·3	1·5	1·6	1·6	1·5 μ.

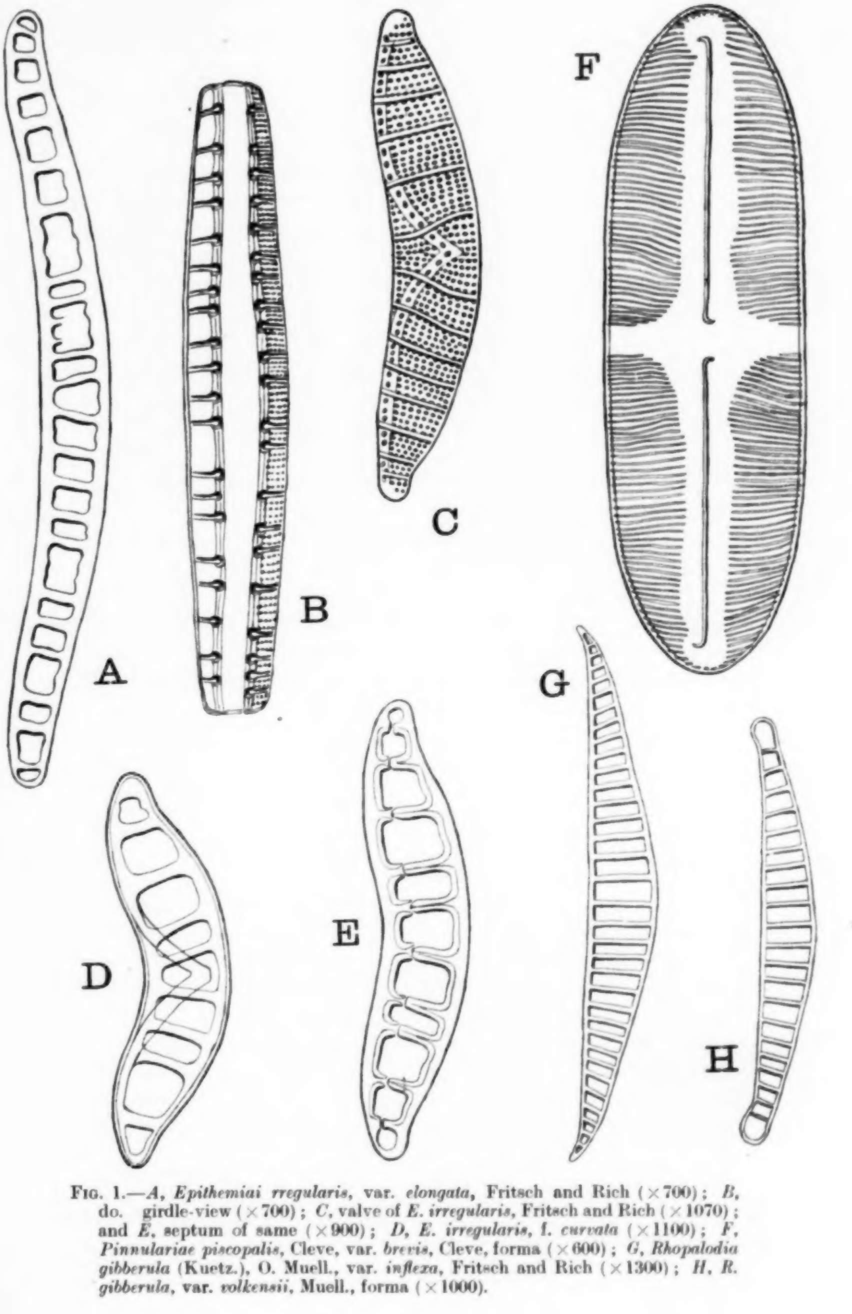


FIG. 1.—*A*, *Epithemiai rregularis*, var. *elongata*, Fritsch and Rich (×700); *B*, do. girdle-view (×700); *C*, valve of *E. irregularis*, Fritsch and Rich (×1070); and *E*, septum of same (×900); *D*, *E. irregularis*, f. *curvata* (×1100); *F*, *Pinnulariae piscopalis*, Cleve, var. *brevis*, Cleve, forma (×600); *G*, *Rhopalodia gibberula* (Kuetz.), O. Muell., var. *inflexa*, Fritsch and Rich (×1300); *H*, *R. gibberula*, var. *volkensii*, Muell., forma (×1000).

This is by far the most abundant Diatom in the Ermelo deposit and occurs in three forms, two of them common, the third rare. Most frequent is what we regard as the type, whose diagnosis is given above. In outward form of the valve-view this species shows much resemblance with some forms of *E. argus*, Kuetz., especially the var. *longicornis*, Grun. (*cf.* W. Smith, Brit. Diat., i, p. 13, Tab. XXX, fig. 24; and Meister, Kieselalgen d. Schweiz, p. 198, Tab. XXXIV, figs. 3, 4), though the ends are more markedly protruded than in the latter. It is, however, at once distinguished from all hitherto published species of *Epithemia* by the fact that the ribs of the valve are placed at quite unequal distances apart (*cf.* Fig. 1, *B, C*). Since, as in *E. argus*, the partitions between the windows of the longitudinal septum arising from the intercalary band correspond in position to the ribs on the valves, the foramina of this septum are also of quite unequal size (Fig. 1, *D, E*). The irregularity makes itself equally apparent in the girdle-view (Fig. 1, *B*), where the horizontal septa, connecting the ribs of the valve with the partitions between the foramina of the septum, are seen to have conspicuously dilated inner ends ("eyes"), as in *E. argus*. The irregularity thus affects the entire structure of the frustule and, in view of its constancy, appears of sufficient importance to warrant the establishment of a new species. The following measurements, which give the lengths of the intervals between successive ribs on three valves selected at random, may serve, in addition to the diagrams, to illustrate the irregular distribution of the ribs :—

4·9; 2·8; 4·9; 5·6; 4·2; 6·3; 11·2; 9·1; 4·9; 4·2; 7·0; 3·5.
3·5; 2·8; 5·6; 3·5; 2·1; 4·2; 4·9; 3·5; 3·5; 7·0; 4·2; 5·6; 2·8.
3·5; 5·6; 4·9; 11·9; 8·4; 4·9; 7·0; 4·9; 8·4; 5·6; 5·6; 8·4; 4·9.

In view of the general similarity of *E. irregularis* to *E. argus*, it may seem rash to base a new species mainly on this irregularity. The published figures of the species of *Epithemia* that we have seen, however, show in nearly all cases such a regular spacing of the costae that the present form seems quite exceptional in this respect.* Moreover, the hitherto known species of *Epithemia* are largely distinguished on the basis of the number of ribs in 10 μ and the numbers of rows of punctae between successive ribs; such distinctions necessarily imply a regular spacing of the ribs, but they are of practically no value in the case of *E. irregularis*, where the number of ribs in 10 μ and the number of intervening rows of punctae vary considerably in different parts of one and the same valve. In a considerable number of

* Van Heurck, Synops. Diat. Belg. (1880–85), shows for *E. argus*, in fig. 16 on Pl. XXXI, some inequality in the size of the foramina of the septum, and in fig. 17 of the girdle-view some irregularity in the spacing of the horizontal septa; the feature is, however, not nearly so marked as in *E. irregularis*.

the specimens incomplete ribs were noted here and there; such ribs usually extended a little way inwards from the ventral margin, but generally stopped far short of the dorsal one. Such cases may indicate the way in which the irregularity has arisen, viz. by abortion of some of the ribs.

In its other characters this species very closely resembles *E. argus*. The two parts of the raphe form practically a right angle with one another and extend about two-thirds of the way across the valve towards the dorsal margin (Fig. 1, *C*). The partitions between the foramina of the longitudinal septum are always broken towards the ventral surface (Fig. 1, *E*), although this fact is often obscured by the overlying ribs of the valve. Meister, to judge by his statement on p. 198 (*loc. cit.*), seems to consider that in *E. argus* it is the costae that are ventrally broken, but, as far as we are aware, it is always only the partitions of the septum, and the feature in question will be readily distinguishable or not according as one examines an isolated septum or an intact valve. The punctae of *E. irregularis* exhibit a very regular arrangement, often not only in transverse but also in rough longitudinal series.

A rather rare form of the species is shown in Fig. 1, *D*. It is characterised by a sharp curvature of the ventral surface, but otherwise resembles the type. It may be designated forma *curvata*. A much more frequent type is that shown in Fig. 1, *A*, which may be described as—

Var. *elongata*, nov. var. (Fig. 1, *A*).

Fere duplo longiore quam typo, latitudine eadem, apicibus minus protrusis et minus recurvatis, margine ventrali valvae concavo vel fere recto, margine dorsali leviter convexo.

Long. valv. .	105·0	132·0	133·0	140·0	150·0	166·0	162·0	186·0 μ.
Lat. ,, .	12·0	12·0	16·0	13·0	14·0	16·0	15·0	21·0 μ.
Costae in 10 μ	1·7	1·2	1·2	1·7	2·0	..	1·1	1·1 μ.

The valves of this variety are almost double as long, while retaining the same width as the type. The apices, too, are not so protruded and often not so sharply recurved. There is also a f. *curvata* of this variety, in which the whole valve is markedly curved.

2. *Epithemia argus*, Kuetz.

The only other species of *Epithemia* present, and very rare by comparison with *E. irregularis*.

3. *Rhopalodia gibberula* (Kuetz.), O. Muell., Hedwigia, XXXVIII, 1899, p. 286 *et seq.*

Specimens of this species were not uncommon and were of two types, both belonging to O. Mueller's section IV: "Valvae mit ventral verbogenen Apices." The majority showed inflexed, but not dilated apices (Fig. 1, *G*),

and thus do not agree with any of the forms of that section distinguished by Mueller (*loc. cit.*). We propose for them the name of—

Var. *inflexa*, var. nov. (Fig. 1, *G*).

Valva margine ventrali recto apicibus subito et distincte inflexis non dilatatis acutis, margine dorsali convexo, costis 4–6 in 10 μ. Long., 46–63 μ; lat. valv., 7–8 μ.

The dorsal surface is usually evenly convex, and only shows to a slight extent the medium hump which is so pronounced in some varieties of this species.

A second rarer form likewise had inflexed ends, but these were conspicuously dilated (Fig. 1, *H*). It would appear to be a form of var. *volkensii*, Mueller (*loc. cit.*, p. 293, Tab. XI, fig. 5), from which it differs in the following respects: The dorsal margin is not as markedly convex in the middle, presenting a more even curve, and the entire ventral margin is straight except for the dilated tips. The dimensions are very similar to those given by Mueller, viz. long., 43–52 μ; lat. valv., 8 μ.

4. *Navicula* (*Pinnularia*) *episcopalis*, Cleve, Act. Soc. Fauna et Flora Fennica, viii, No. 2, 1891, p. 27, Pl. 1, fig. 4; Synops. Naviculoid Diat., ii. p. 80.

Var. *brevis*, Cleve, Synops., ii, p. 80; Meister, *op. cit.*, p. 154, Tab. XXVI, fig. 2.

Forma *lata*, valvis latioribus, costis medianis saepe vix radiantibus. Long., 154–240 μ; lat. valv., 44–57 μ; costis ca. 6 in 10 μ (Fig. 1, *F*).

This large and handsome form was rather abundant, but the specimens differed from those described by Cleve and Meister in possessing a greater relative breadth and particularly in the fact that the median ribs often radiated but very slightly.

5. *Navicula* (*Pinnularia*) *major*, Kuetz., Bacill., p. 97; W. Smith, Brit. Diat., i, p. 54; Cleve, Synops., ii, p. 89.

Var. *linearis*, Cleve, Synops., ii, p. 89; Meister, *op. cit.*, p. 153, Tab. XXV, fig. 3.

Long., 150–178 μ; lat. valv., 28–32 μ; costae in middle 8, elsewhere 6 in 10 μ.

Rarer than No. 4, but not infrequent. It is difficult to understand why Cleve (*op. cit.*) made Smith's figure of *P. major* (*op. cit.*, Pl. XVIII, fig. 162) the type of his var. *linearis*, since Smith's figure shows the median inflation which is characteristic of the type. Meister figures the variety without any median inflation. Our specimens showed an occasional tendency in this direction, but the enlargement was never marked. A considerable number of the valves had rather pointed ends, agreeing in this respect with Smith's rather than with Meister's figure.

6. *Navicula* (*Pinnularia*) *viridis*, Ehrenb., var. *elliptica*, Meister, *op. cit.*, p. 150, Tab. XXIII, fig. 4.

Long., 73–90 μ; lat. valv., 16–18 μ; striae 8 in 10 μ.

Also rather frequent.

7. *Navicula* (*Pinnularia*) *borealis*, Ehrenb.; Cleve, Synops., ii, p. 80.

Not uncommon. Long., 34–37 μ; lat. valv., 8–9 μ; var. *scalaris*, Grun., with the ribs missing in the middle of the valve, also present but rarer.

8. *Navicula* (*Pinnularia*) *interrupta*, W. Smith, *op. cit.*, i, p. 59, Pl. XIX, fig. 184.

f. westii, Fritsch, Ann. S. Afr. Mus., ix, p. 592 (*P. bicapitata*, G. S. West, Journ. Linn. Soc., Bot., xxxix, 1909, p. 78, Pl. III, fig. 13).

Very rare.

9. *Navicula* (*Diploneis*) *elliptica*, Kuetz.; Cleve, Synops., i. p. 92.

This was the commonest Diatom present after *Epithemia irregularis*. The specimens varied very considerably in length (24–36 μ), but were otherwise typical.

10. *Navicula* (*Anomoeoneis*) *sphaerophora*, Pfitzer; Cleve, Synops., ii, p. 6; Meister, *op. cit.*, p. 117, Tab. XVII, fig. 7.

Very rare. Long., 60–68 μ; lat. valv., 18–19 μ.

11. *Navicula* (*Neidium*) *bisulcata*, Lagerstedt, Bih. K. Sv. Vet.-Ak. Handl., i, No. 14, 1873, t. i, p. 8; var. *undulata*, O. Muell., Forschungsber. Biol. Stat. Plön., vi, 1898, p. 62.

Likewise very rare. Long., 34 μ; lat. valv., 7 μ.

12. *Stauroneis anceps*, Ehrenb., var. *birostris* (Ehrenb.), Cleve, Synops., i, p. 147; Meister, p. 124, Tab. XVIII, fig. 11.

Rare. Long., 48–58 μ; lat. valv., 15–18 μ.

13. *Cymbella helvetica*, Kuetz.; Cleve, Synops., i, p. 174; Meister, *op. cit.*, p. 180.

Forma margine dorsali convexo, margine ventrali fere recto inflatione mediana exigua; striis robustis, saepe ventre minus dense dispositis quam dorso, paullo radiantibus. Long., 56–81 μ; lat. valv., 15–19 μ; striis, 8–10 in 10 μ.

This form is moderately frequent. In the shape of the valve it approaches var. *africana*, Fritsch and Rich, (Proc. Roy. Soc. S. Africa, XI, 1924, p. 390, fig. 30, *K*), but the striae are not so strongly radiating as there and it is the ventral, rather than the dorsal, striae that are more widely spaced.

14. *Cymbella cuspidata*, Kuetz.; Cleve, *op. cit.*, p. 166; Meister, *op. cit.*, p. 186, Tab. XXXI, fig. 18.

Forma margine ventrali minus convexo, saepe fere recto. Long., 42 μ; lat. valv., 10–12 μ.

This species was rarer than the last. The ventral margin, although

prominently protruded just before the poles, was almost straight throughout the greater part of its length. Otherwise the specimens were altogether typical.

15. *Nitzschia palea*, W. Smith, Brit. Diat., ii, p. 89; Meister, *op. cit.*, p. 213, Tab. XXXVIII, fig. 9.

Diverse forms of this small species were present, but none occurred in any quantity. Long., 22–42 μ; lat. valv., 3–6 μ.

16. *Hantzschia amphioxys*, Grun.; Meister, *op. cit.*, p. 203, Tab. XXXVI, fig. 2.

Only very few specimens seen. Long., 56 μ; lat. valv., 9·5 μ. Also var. *pusilla*, Dippel (long., 29–35 μ; lat. valv., 6 μ).

17. *Gomphonema* sp.

Very rare, and too few individuals seen to make sure of a determination; probably a form of *G. parvulum*, Grun.

Although seventeen species of Diatoms have thus been distinguished in the kieselguhr, the bulk of the deposit is composed of six, viz. *Epithemia irregularis*, *Navicula* (*Diploneis*) *elliptica*, *Pinnularia episcopalis* var. *brevis*, *P. major* var. *linearis*, *P. viridis* var. *elliptica*, and *Cymbella helvetica*. The complete absence of all Diatoms of the centric type, of all colonial forms, and of such common genera as *Surirella* and *Synedra* is noteworthy.

It is interesting to compare the composition of this deposit with that of a diatomaceous earth described by G. S. West from near Choma in north-west Rhodesia.* In the latter the dominant forms were *Epithemia argus* and two varieties of *Rhopalodia gibberula*; for the rest the matrix consisted of species of *Pinnularia* (incl. *P. viridis*), *Navicula* (*Diploneis*) *elliptica*, *Mastogloia grevillei*, *Surirella ovalis* var. *ovata*, etc. Whilst there are obvious resemblances, the Ermelo deposit differs from the Rhodesian one in the fact that a larger number of Diatoms play a dominant part in its formation.

* G. S. West, "Algological Notes," V, Journ. of Bot., 1912, p. 79.

A COLLECTION OF HETEROSOMATA FROM PORTUGUESE EAST AFRICA.

By Cecil von Bonde, M.A., Ph.D., Senior Lecturer in Zoology, University of Cape Town.

The present paper is based on a collection of Heterosomata (Flat-fish) from Portuguese East Africa, made by Dr. J. D. F. Gilchrist and the late Mr. H. A. T. Hunter.

The collection comprises twenty species belonging to sixteen different genera. One species, *Pardachirus marmoratus* (Lacépède), is of particular interest, having only been described from the Red Sea and Madagascar, and is now recorded from Delagoa Bay.

Two new species, *Samaris delagoensis* and *Cynoglossus hunteri*, are here described for the first time.

In their distribution the Heterosomata of Portuguese East Africa are closely related to those of Natal waters, and some new species recently described from Natal * have now been found in this region.

The following is a list of species found in the collection :—

Suborder HETEROSOMATA.

Family I PLEURONECTIDAE.

Genus Platophrys.

1. *Platophrys pantherinus* (Rüppell).

Genus Crossorhombus.

2. *Crossorhombus dimorphus* (Gilchrist).

Genus Scaeops.

3. *Scaeops grandisquama* (Schlegel).

Genus Engyprosopon.

4. *Engyprosopon natalensis*, Regan.

* von Bonde, C., "The Heterosomata collected by the S.S. 'Pickle,'" Fish. and Mar. Biol. Report No. 2, for the Year 1921 ; Special Report No. 1 (1922).

Genus Arnoglossus.

5. *Arnoglossus macrolepis*, Gilchrist.

Genus Chascanopsetta.

6. *Chascanopsetta gilchristi*, von Bonde.

Genus Lambdopsetta.

7. *Lambdopsetta pectoralis*, von Bonde.

Genus Laeops.

8. *Laeops nigromaculatus*, von Bonde.

Genus Samaris.

9. *Samaris delagoensis*, sp. n.

Genus Pseudorhombus.

10. *Pseudorhombus russellii* (Gray).
11. *Pseudorhombus natalensis*, Gilchrist.

Family II SOLEIDAE.

Genus Pardachirus.

1. *Pardachirus marmoratus* (Lacépède).

Genus Solea.

2. *Solea turbynei*, Gilchrist.

Genus Aesopia.

3. *Aesopia cornuta*, Kaup.

Genus Cynoglossoides.

4. *Cynoglossoides attenuatus* (Gilchrist).

Genus Areliscus.

5. *Areliscus marleyi* (Regan).
6. *Areliscus microphthalmus*, von Bonde.
7. *Areliscus capensis* (Kaup).

Genus Cynoglossus.

8. *Cynoglossus hunteri*, sp. n.
9. *Cynoglossus gilchristi*, Regan.

Suborder HETEROSOMATA.

Family I PLEURONECTIDAE, *Flemming*.

Genus Platophrys, *Swainson*.

1. Platophrys pantherinus (*Rüppell*).

   Rhomboidichthys pantherinus (Rüpp.), Günther, Cat. Fish., iv, p. 436 (1862).

   Platophrys pantherinus, Bleeker, Atl. Ichth., vii, p. 11, pl. ccxxxiii, fig. 3 (1866); von Bonde, *op. cit.*, p. 6 (1922).

   Bothus pantherinus, Regan, Ann. Durban Mus., ii, pt. 5, p. 212, fig. 3 (1920).

Localities.—A number of specimens, varying in length from 70 to 190 mm., were procured from the Lourenço Marques Fish Market; shore collecting, N.W. Inhaca; and Delagoa Bay, 54 fms., bottom sand.

Distribution.—This species has been recorded from Natal by Regan, *loc. cit.*, and the distribution is from the Eastern Coasts of Africa to the Fiji Islands (Pacific).

Genus Crossorhombus, *Regan*.

2. Crossorhombus dimorphus (*Gilchrist*).

   Platophrys dimorphus, Gilchrist, Mar. Inv. S. Afr., iii, p. 10, pl. xxvii (1905).

   Crossorhombus dimorphus, Regan, *op. cit.*, p. 212 (1920); von Bonde, *op. cit.*, p. 6 (1922).

Localities.—A number of specimens were procured from the Lourenço Marques Fish Market; 4¾ miles S. 47° E. from Leck Reef in 11 fms., bottom sand; Delagoa Bay, 17 metres, bottom sand. Five specimens, the largest being 125 mm., were also procured from Delagoa Bay, but the exact locality is not given.

Distribution.—This species is endemic, occurring on the East Coast of South Africa, mostly in shallow water.

Genus Scaeops, *Jordan and Starks*.

3. Scaeops grandisquama (*Schlegel*).

   Rhombus grandisquama Schlegel, Faun. Japon. Poiss., p. 183, pl. 92, figs. 3 and 4.

   Rhomboidichthys grandisquama, Günther, Cat. Fish., iv, p. 437 (1862).

Engyprosopon grandisquama, Jordan and Synder, Fish. Japan, Annot. Zool. Jap. Check-list, 190, p. 122.

Platophrys grandisquama, Gilchrist, Mar. Inv. S. Afr., iv, p. 161 (1908).

Scaeops grandisquama, Jordan and Starks, Proc. U.S. Nat. Mus., 31, p. 168, fig. 1 (1907); von Bonde, *op. cit.*, p. 6 (1922).

Locality.—Two specimens, 75 mm. in length, were obtained from Delagoa Bay, 54 metres, bottom sand.

Distribution.—This species has a wide range, having been recorded from the East Coast of Natal, near the Amatikula River; from Delagoa Bay; from Wakanoura and Nagasaki; Chinese and Japanese Seas; and from the N.W. Coast of America.

Genus Engyprosopon, *Günther.*

4. Engyprosopon natalensis, *Regan.*

Engyprosopon natalensis, Regan, *op. cit.*, p. 211 (1920); von Bonde, *op. cit.*, p. 6 (1922).

Locality.—A single specimen, 55 mm. in length, was procured from 4¾ miles S. 47° E. Leck Reef, depth 11 fms., bottom sand.

Distribution.—This is a species endemic to the East Coast, having been recorded before only from off the mouth of the Amatikulu River, 26–27 fms.

Genus Arnoglossus, *Bleeker.*

5. Arnoglossus macrolepis, *Gilchrist.*

Arnoglossus macrolepis, Gilchrist, Mar. Inv. S. Afr., iii, p. 12, pl. xxxvi (1905); von Bonde, *op. cit.*, p. 6 (1922).

Localities.—A few mature specimens were procured from ¾ miles S. 74·5° W. from Chefina Light, 8 fms., bottom sand; Delagoa Bay, 260 metres, bottom sand and shells.

Distribution.—Endemic species occurring off the Coast of Natal.

Genus Chascanopsetta, *Alcock.*

6. Chascanopsetta maculata, *von Bonde.*

Chascanopsetta maculata, von Bonde, *op. cit.*, p. 8, pl. ii, fig. 1 (1922).

Locality.—A single specimen, much damaged, 175 mm. long, was procured from Delagoa Bay, 455 metres, bottom sand.

Distribution.—A few specimens have been obtained before in deep water off the Natal Coast.

Genus Lambdopsetta, *Smith and Pope.*

7. Lambdopsetta pectoralis, *von Bonde.*

Lambdopsetta pectoralis, von Bonde, *op. cit.*, p. 10, pl. i, fig. 3 (1922).

Locality.—Two specimens, 170 mm. in length, were procured, together with other specimens, from Delagoa Bay; but the exact locality is not stated.

Distribution.—Two specimens have been recorded from the Natal Coast.

Genus Laeops, *Günther.*

8. Laeops nigromaculatus, *von Bonde.*

Laeops nigromaculatus, von Bonde, *op. cit.*, p. 10, pl. iii (1922).

Locality.—A single specimen, 160 mm. long, was procured, together with the preceding species, from Delagoa Bay; the exact locality is not stated.

Distribution.—The type specimen was procured off the Natal Coast.

Genus Samaris, *Gray.*

9. Samaris delagoensis, sp. n.

D. 15+63; A. 55; P. 4; C. 15; V. 5; L. 1, 94; head, 5 in length; depth, 2·75; eye, 3·75 in head; pectoral, 1·15 in head.

Eyes on right side, upper slightly in advance of lower and separated by a blunt interorbital ridge; snout has deep concavity in front of upper eye; nostrils lie in front of lower eye and have a bifurcated tubular flap of skin; mouth almost vertical, lower jaw being slightly longer than upper; maxillary reaches to vertical through anterior border of lower eye; teeth very fine, in bands on both jaws; preopercular margin curved and free; dorsal commences on horizontal through upper border of upper eye, slightly on blind side, and extends to base of caudal; first 15 rays elongated and filamentous, all about equally long and 1·3 in length of body without caudal; dorsal and anal rays increase in length posteriorly, longest ray of dorsal and anal being equal in length and 1·3 in length of head; caudal bluntly pointed; ventrals symmetrically placed, each with 5 rays; rays of right ventral elongated, 1st being long and free and 1·2 times length of head, bearing a flattened elongated, oval-shaped piece of skin on its end; 2nd ray similar to 1st, almost of same length, but attached by a membrane to the 3rd; 3rd ray is 1·2 in head and also ends in a swollen pad of skin; last ray of right ventral attached to anal by a thin membrane, sinistral ventral normal; right pectoral narrow and 1·2 in head; pectoral of blind side absent.

Body long and slender, with nearly parallel outlines; caudal peduncle broad; lateral line well developed on right side, commencing at posterior end of interorbital ridge and rising till over vertical through preoperculum, thence passing straight backwards; at point where the bend in the line

occurs there is a small portion of the lateral line running dorsalwards through about 4 scales; scales ctenoid on both sides, stronger on eyed side.

Colour dark, with blotches of various sizes scattered all over body and fins; 3rd, 5th, 6th, and 10th elongated dorsal rays have their bases blackish; ventrals very dark; pectorals dark, with mottlings of black; posterior ends of anal and dorsal and whole caudal with lighter mottlings; ends of first 3 dextral ventral rays blackish.

Length of largest specimen, 170 mm.

Locality.—Three specimens, ranging from 150–170 mm., were procured from Delagoa Bay.

In my review of the Heterosomata of South Africa, *op. cit.*, p. 13, pl. vi, I described a new species belonging to the same genus, viz. *S. ornatus*, from Natal. The above species, which is very different from *S. ornatus*, forms the second species of the genus *Samaris* recorded from S. African waters.

Genus Pseudorhombus, *Bleeker.*

10. Pseudorhombus russellii (*Gray*).

Pseudorhombus russellii (Gray), Günther, Cat. Fish., iv, p. 424 (1862); Bleeker, Atl. Ichth., vi, p. 6, Pleuron., pl. ii, fig. 2 (1866); Gilchrist, Ann. S. Afr. Mus., vi, pt. 2, p. 263 (1902); Regan, *op. cit.*, p. 208 (1920); von Bonde, *op. cit.*, p. 15 (1922).

Localities.—A number of specimens, the largest being 240 mm. in length, were procured from the Lourenço Marques Fish Market; $1\frac{1}{2}$ miles S. 20° E. from Chefina Light, depth 6 fms., bottom sand.

Distribution.—Durban Harbour, near mouth of Umbilo River; Delagoa Bay; East Coast of India; Bay of Bengal; Andaman Islands; Java Sea; Coast of China; East Indies; and Coast of New South Wales.

11. Pseudorhombus natalensis, *Gilchrist.*

Pseudorhombus natalensis, Gilchrist, Mar. Inv. S. Afr., iii, p. 8, pl. xxv (1905); von Bonde, *op. cit.*, p. 15 (1922).

Locality.—Seven small specimens, the largest being 135 mm., were procured from Delagoa Bay.

Distribution.—This species is of common occurrence off the Natal Coast in depths from 25–230 fms.

Family II SOLEIDAE, *Gill.*

Genus Pardachirus, *Günther.*

As this genus is here recorded from South African waters for the first time, the generic characters are given in detail. The genus is near *Achirus*, Lacépède, and belongs to the subfamily Achirinae.

Pardachirus, Günther, Cat. Fish., iv, p. 487 (1862).

Eyes and colour on right side, upper eye slightly in advance of lower. Mouth unsymmetrical, small, more developed on blind side. Teeth minute, on blind side only (in present specimen teeth appear to be totally absent). Dorsal and anal rays scaled, with pores at bases. Dorsal commences on snout and terminates on caudal peduncle. Pectorals absent. Caudal free from dorsal and anal. Ventrals well developed, symmetrical. Scales moderate, cycloid. Lateral line straight, with an accessory branch on blind side, commencing on snout and running along upper profile of the neck. Gill-opening narrow, gill-membrane broadly united below throat.

1. Pardachirus marmoratus (*Lacépède*).

Achirus marmoratus, Lacépède, iv, pp. 658, 660; Geoffr., Ann. Mus., i, p. 152, tab. 11; Rüpp., Atl. Fische, p. 122, tab. 31, fig. 2.
Pardachirus marmoratus, Günther, Cat. Fish., iv, p. 478 (1862).

Locality.—A single specimen, 260 mm. long, was procured from Bazaruto (St. Carolina), shore collecting amongst coral.

This fish is apparently identical with Günther's *P. marmoratus* described from Eastern Coasts of Africa, agreeing very closely with it in radial formula. The only difference lies in the coloration. In the present specimen there are no "scattered white ocelli edged with brown and with a brown spot in the centre."

Distribution.—Red Sea and Madagascar.

Genus Solea, *Lacépède*.

2. Solea turbynei, *Gilchrist*.

Solea turbynei, Gilchrist, Mar. Inv. S. Afr., iii, p. 10, pl. xxviii (1905); von Bonde, *op. cit.*, p. 17 (1922).

Localities.—A number of small specimens were procured from the Lourenço Marques Fish Market; and ¾ mile N. 26° E. from Wreck Light, in 4 fms., bottom mud.

Distribution.—This species is endemic to South Africa and has a very wide range, occurring on the West Coast (Berg River), South and East Coasts as far north as Delagoa Bay.

Genus Aesopia, *Kaup*.

3. Aesopia cornuta, *Kaup*.

Aesopia cornuta, Kaup, Wiegm. Archiv, p. 95 (1858); Regan, *op. cit.*, p. 218 (1920); von Bonde, *op. cit.*, p. 21 (1922); Günther, Cat. Fish., iv, p. 487 (1908).

Synaptura cornuta, Day, Proc. Zool. Soc., p. 238 (1873); and Fish. Ind., p. 430, pl. xciv, fig. 4; Gilchrist, Mar. Inv. S. Afr., iv, p. 161 (1908).

Locality.—A single specimen, 150 mm. in length, was procured from Delagoa Bay.

Distribution.—India, north to Nagasaki; Natal; Delagoa Bay.

Genus CYNOGLOSSOIDES, *von Bonde.*

4. Cynoglossoides attenuatus (*Gilchrist*).

Cynoglossus attenuatus, Gilchrist, Mar. Inv. S. Afr., iii, p. 11, pl. xxix (1905).

Cynoglossoides attenuatus, von Bonde, *op. cit.*, p. 23 (1922).

Localities.—A number of specimens up to 225 mm. in length were procured from Lourenço Marques Fish Market; ½ mile S. 58° E. from Chefina Light, in 6 fms., bottom sand; ½ mile S. 20° E. from Chefina Light, in 5 fms., bottom sand; and Delagoa Bay, 3 fms., bottom mud, shells.

Distribution.—This species is found in large numbers off the Natal Coast.

Genus ARELISCUS, *Jordan and Synder.*

5. Areliscus marleyi (*Regan*).

Cynoglossus marleyi, Regan, Ann. Mag. Nat. Hist. (9), vii, p. 418 (1921).

Areliscus marleyi, von Bonde, *op. cit.*, p. 25 (1922).

Locality.—A single specimen was obtained from Delagoa Bay in 17 metres, bottom mud, sand, shells.

Distribution.—Off Natal Coast.

6. Areliscus microphthalmus, *von Bonde.*

Areliscus microphthalmus, von Bonde, *op. cit.*, p. 24, pl. iv, fig. 3 (1922).

Locality.—Three specimens were obtained from Delagoa Bay in 415 metres, bottom sand.

Distribution.—This species occurs off the Natal Coast.

7. Areliscus capensis (*Kaup*).

Trulla capensis, Kaup, Arch. f. Nat., p. 109 (1858).

Cynoglossus capensis, Günther, Cat. Fish., iv, p. 503 (1862); Boulenger, Mar. Inv. S. Afr., i, p. 4 (1902).

Areliscus capensis, von Bonde, *op. cit.*, p. 24 (1922).

Locality.—Two specimens were obtained from Delagoa Bay.

Distribution.—This species is endemic to South Africa, and has a very wide range similar to *Solea turbynei*, occurring on the West, South, and East Coasts.

Genus Cynoglossus, *Buchanan-Hamilton*.

In my review of the Heterosomata of South Africa, *op. cit.*, on p. 22 the following key to the South African genera of the Cynoglossinae is given :—

A. Lateral line (or lines) present on eyed side, sometimes also on blind side.
- (*a*) Lips fringed ; blind side with or without lateral line.
  - α. Eyed side with 2 lateral lines ; blind side none *Plagusia*, 1.
  - β. Eyed side with 2 lateral lines ; blind side 1 *Paraplagusia*, 2.
- (*b*) Lips not fringed ; blind side with or without lateral line.
  - α. 2 lateral lines on each side . . . *Cynoglossoides*, 3.
  - β. 3 lateral lines on each side ; 1 on blind side (sometimes very faint) . . . . *Areliscus*, 4.
  - γ. 2 lateral lines on eyed side ; none on blind side *Cynoglossus*, 5.

B. Lateral line absent ; lips not fringed . . *Symphurus*, 6.

Amongst this collection of fishes a specimen belonging to the sub-family Cynoglossinae was found having 2 lateral lines on the eyed side, and 1 on the blind side. Some species having the same arrangement of lateral lines have been described by Day, Fish. Ind., p. 432, under the genus *Cynoglossus*. The species in question somewhat resembles *C. lingua*, op. cit., p. 433, and doubtless belongs to the same genus. Thus the above key may be amended to read :—

γ. 2 lateral lines on eyed side, 1 or none on blind side *Cynoglossus*, 5.

8. Cynoglossus hunteri, sp. n.

D. 130 ; A. 98 ; L. 1, 97 ; depth, 4·5 in length ; head, 5 ; eye, 8 in head.

Eyes on left side narrowly separated, upper in advance of lower by about 0·25 diameter ; anterior nostril tubular, in front of lower eye, posterior nostril between anterior margins of eyes ; mouth moderate, curved, maxillary, reaching to vertical through posterior border of lower eye ; teeth very small and few, on blind side only ; snout almost equal to postorbital length of head, sharply rounded and hooked ; dorsal and anal confluent with caudal ; ventral fin separated from anal.

Body very elongated, thin ; scales strongly ctenoid on eyed side, cycloid on blind side ; 2 lateral lines on eyed side, upper running parallel to dorsal profile to anterior border of snout, where it curves round and turns back to run as a straight line above upper eye, meeting lower lateral line ; at point of junction there is a vertical connection between upper and lower lines ;

lower line runs in middle of body, straight on to caudal, and has 97 scales; dorsal line continues round anterior border of snout, and then extends backwards towards anterior nostril, where it gives rise to two short branches; a single lateral line on blind side in centre of body.

Colour uniform brownish, operculum darker.

Length of specimen, 78 mm.

Locality.—This single specimen was procured from ¼ mile S. 41° E. from Pt. Vermetha, in 3 fms., bottom mud and shells.

The specimen is named after the late Mr. H. A. T. Hunter, who collected the majority of the specimens described in the present paper.

9. Cynoglossus gilchristi, *Regan.*

Cynoglossus brachycephalus (*non* Bleeker), Gilchrist, Mar. Inv. S. Afr., iii, p. 12, pl. xxx (1905); von Bonde, *op. cit.*, p. 25 (1922).

Cynoglossus gilchristi, Regan, Ann. Durban Mus., ii, pt. 5, p. 222 (1920).

Locality.—The specimen was procured from 2¼ miles N. 50° E. from Chefina Light, in 4 fms., bottom sand.

The discovery of *Pardachirus marmoratus*, *Samaris delagoensis*, and *Cynoglossus hunteri*, brings the total number of species of Heterosomata found in South African Seas up to fifty-three. They are divided amongst twenty-eight genera.

PERIODICITY IN RAINFALL.

By G. W. Cox.

(With two Text-figures.)

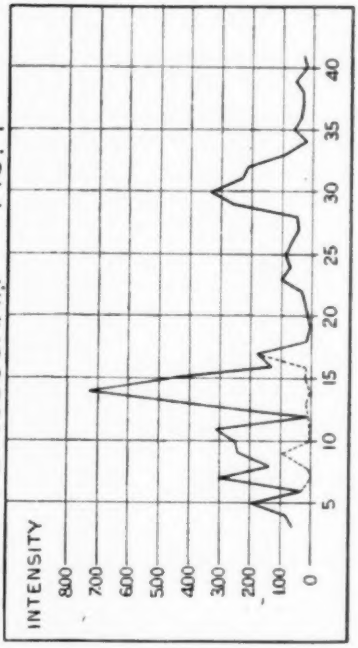
A cursory inspection of any table of annual rainfall values discloses irregularities which suggest the results of pure chance. In many cases—Cape Town rainfall may be cited as an example—a more rigorous examination shows that the magnitudes of fluctuations in quantity about some particular value follow closely Gauss' law of errors. Chance, however, does not exist in nature, and the apparent fortuitous character of events must be attributed to the operation of a number of independent causes too complex for separation in the present state of knowledge.

In the above, variations in magnitude have been specially mentioned; but there is another important consideration. A vital question in long-range weather forecasting, implying as it does a knowledge of the laws governing the sequence of weather phenomena, is whether the values of data follow any law of succession separable from the law of chance as already defined. The possibility of discovering such a law appeals strongly to the imagination, and numerous attempts, amongst which Bruckner's is probably best known, have been made. Notwithstanding these, the existence of any cycle in rainfall has not yet been indisputably established; and the investigation described below, on the lines of the method adopted by Professor Schuster,* was not expected to yield incontrovertible results.

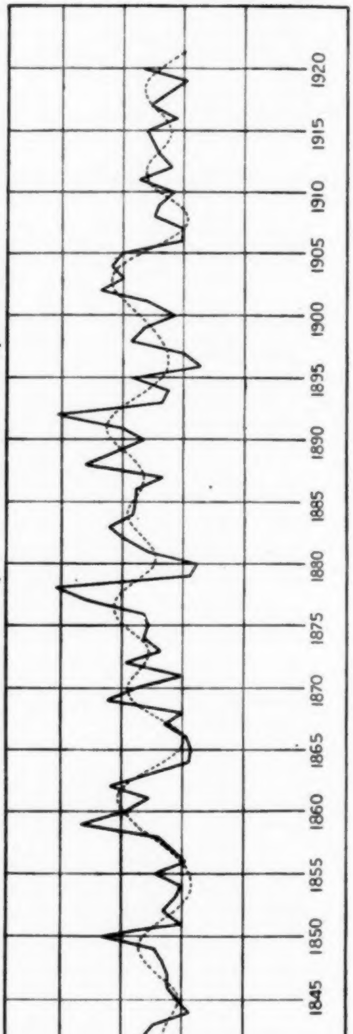
The longest rainfall record available in South Africa is that of the Royal Observatory, Cape Town, where observations commenced in 1841. The annual amounts recorded since that year, supplemented by data obtained in the vicinity during the three preceding years, are shown in Table I. These eighty-three successive annual values were tabulated in rows in the usual manner, and the coefficients of the first harmonics in the Fourier series, corresponding to trial periods from 3 to 41 years, were then determined. The results appear in Table II, and are depicted graphically in the

* Trans. Roy. Soc., vol. 206, A; Trans. Cambridge Phil. Soc., vol. xvii.

PERIODOGRAM —— FIG. 1



CAPETOWN RAINFALL (ROYAL OBSERVATORY) —— FIG. 2



Periodogram (fig. 1), constructed by taking trial periods as abscissae and the values of (A^2+B^2) as ordinates.

The most outstanding feature in this figure is the rise of the periodograph at the 14-year trial period, the value of the ordinate being 5·2 times the mean of the squares of all amplitudes considered. Taking the latter as the measure of intensity of the whole periodogram, the probability that the amplitude of this period is the result of pure chance is about 1 in 200. Additional evidence of its existence is found in the manner in which ordinates for adjacent trial periods are affected, and the rise of the periodograph at 7 years; whilst, on the other hand, 83 years is far too short a record on which to base any definite conclusions regarding a period of 14 years in length.

TABLE I.—*Annual Rainfall—Cape Town* (*Royal Observatory*).

Year.	Inches.	Year.	Inches.	Year.	Inches.	Year.	Inches.
1838	24·44	1859	36·72	1880	17·71	1901	25·66
1839	17·48	1860	29·12	1881	25·61	1902	33·74
1840	25·06	1861	25·44	1882	29·31	1903	29·92
1841	23·21	1862	32·01	1883	32·06	1904	31·82
1842	26·27	1863	25·60	1884	28·29	1905	30·15
1843	24·82	1864	18·92	1885	27·92	1906	20·26
1844	18·78	1865	18·67	1886	27·79	1907	19·89
1845	20·91	1866	19·21	1887	23·08	1908	24·72
1846	22·50	1867	22·97	1888	36·06	1909	24·01
1847	22·38	1868	19·95	1889	30·98	1910	21·56
1848	23·25	1869	32·34	1890	26·34	1911	27·42
1849	24·62	1870	28·06	1891	30·30	1912	22·01
1850	33·47	1871	20·11	1892	40·92	1913	24·01
1851	20·31	1872	29·33	1893	23·42	1914	25·02
1852	23·19	1873	23·77	1894	22·55	1915	26·00
1853	21·22	1874	26·20	1895	28·52	1916	21·20
1854	20·05	1875	25·71	1896	17·07	1917	25·31
1855	24·57	1876	26·64	1897	19·92	1918	22·38
1856	19·48	1877	35·56	1898	28·78	1919	19·59
1857	22·04	1878	41·02	1899	26·79	1920	26·98
1858	24·27	1879	18·74	1900	21·24		

Between 8 and 12 years the curve is found to represent the combined effects of two periods, one of 8·4 and one of 10·5 years. Another rise occurs at 30 years, and although the amplitude is not great and the number of recurrences only two, some confirmation is afforded of the period of that

length found by Professor J. T. Morrison.* The broken line of fig. 1 shows the form taken by the periodograph after removal of the 14, 10·5, 8·4, and 7-year periods, and their effects, as tabulated in Table III.

It will be noticed that the periods of 14, 10·5, 8·4, and 7 are all sub-multiples of 84 years. The whole curve shows a large amplitude for that period, and fig. 2 graphs the data dealt with and the curve.

$$f(t)=25{\cdot}36+2{\cdot}93\sin(mt+249^\circ{\cdot}75)+2{\cdot}71\sin(6mt+221^\circ{\cdot}1)$$
$$+2{\cdot}02\sin(8mt+53^\circ{\cdot}5)+1{\cdot}75\sin(10mt+233^\circ{\cdot}8),$$

where $m=\frac{2\pi}{84}$. It will be seen that this curve represents the date fairly well; but there is, of course, no justification for any claim as to its utility in forecasting.

TABLE II.

Trial period in years.	A.	B.	A^2+B^2.	Trial period in years.	A.	B.	A^2+B^2.
3	+0·63	+0·51	0·6570	23	+0·80	−0·64	1·0419
4	+0·92	−0·06	0·8592	24	+0·36	−0·79	0·7537
5	+1·39	−0·10	1·9421	25	−0·64	−0·68	0·8773
6	−0·15	−0·57	0·3459	26	−0·16	−0·81	0·6865
7	−1·75	+0·04	3·0641	27	−0·17	−0·65	0·4576
8	+0·21	−1·16	1·3897	28	−0·55	−0·45	0·5021
9	−0·73	+1·35	2·3554	29	−0·64	−1·45	2·5237
10	−0·26	+1·54	2·4392	30	−1·40	−1·16	3·2940
11	+1·60	−0·78	3·1684	31	−1·35	−0·69	2·2987
12	+0·01	+0·24	0·0577	32	−1·42	−0·27	2·0900
13	+1·37	−1·35	3·7594	33	−0·94	+0·08	0·8864
14	−1·78	−2·04	7·3300	34	−0·46	+0·03	0·2082
15	−2·00	+0·97	4·9409	35	−0·67	+0·41	0·6172
16	−0·03	+1·17	1·3698	36	−0·58	+0·25	0·3984
17	+1·28	+0·33	1·7575	37	−0·46	+0·33	0·3231
18	+0·29	−0·32	0·1876	38	−0·40	+0·45	0·3639
19	−0·12	−0·02	0·0156	39	+0·18	+0·74	0·5823
20	+0·10	+0·36	0·1430	40	−0·08	+0·45	0·2077
21	+0·41	+0·24	0·2251	41	−0·13	+0·54	0·3079
22	+0·58	−0·11	0·3434				

* Report of Cape Meteorological Commission, 1900, p. 195.

TABLE III.

Trial period in years.	Cosine coefficients. Data.	Cosine coefficients. Due to periods 8·4 and 10·5 years.	Residue.	Sine coefficients. Data.	Sine coefficients. Due to periods 8·4 and 10·5 years.	Residue.	Sum of residues².
8	+0·21	+0·57	−0·36	−1·16	−1·00	−0·16	0·1552
9	−0·73	−0·07	−0·66	+1·35	+0·72	+0·63	0·8325
10	−0·26	−0·36	+0·10	+1·54	+1·54	±0·00	0·0100
11	+1·60	+1·63	−0·03	−0·78	−0·68	−0·10	0·0109
		Due to 14-year period.			Due to 14-year period.		
13	+1·37	+1·08	+0·29	−1·35	−1·64	+0·29	0·1682
15	−2·00	−2·17	+0·17	+0·97	+0·57	+0·40	0·1889
16	−0·03	−0·21	+0·18	+1·17	+0·84	−0·33	0·1413

A SOUTH AFRICAN LIFE TABLE BASED ON THE EUROPEAN MALE POPULATION CENSUS.

By C. W. Kops (University of the Witwatersrand, Johannesburg).

(With Graphs I and II.)

One of the earliest attempts at the construction of a South African life table was that of Mr. Gordon, one time Actuary of the South African Mutual Life Assurance Association. Mr. Gordon's table was based on the experience of the office during the period 1845–1895.

A table was also prepared by the late Dr. Maynard about 1906, based on a census of the European population of Johannesburg. Both these tables are referred to later.

In this paper an attempt has been made at constructing a table based on the censuses of 1918 and 1921, and the deaths during the triennium 1919–1921.

The population on 1st July 1920 was interpolated for as follows :—

Population 1920=population 1st May 1918+0·72222 (population 1921 −population 1918). This gave the values of L_x, the number living aged x. The values of d_x (the number who die aged x) were taken as the average of the deaths during the three years 1919 to 1921.

q_x—the probability that a person aged x shall die within one year$=\dfrac{d_x}{L_x+\frac{1}{2}d_x}$.

It was decided to graduate the values of q_x, rather than graduate L_x and d_x, and then calculate q_x. This latter method was used in the construction of the English National Insurance Act Life Tables of 1911.

The ungraduated values of q_x are given in the following table :—

Age.	q_x.	Age.	q_x.	Age.	q_x.
0	0·09318	33	0·00679	66	0·03846
1	·02556	34	·00682	67	·04621
2	·00954	35	·00873	68	·04291
3	·00583	36	·00896	69	·05628
4	·00390	37	·00866	70	·05444
5	·00344	38	·00922	71	·06565
6	·00290	39	·00969	72	·06900
7	·00269	40	·00792	73	·06865
8	·00241	41	·01025	74	·07951
9	·00212	42	·00995	75	·07913
10	·00226	43	·01063	76	·08829
11	·00199	44	·01976	77	·07724
12	·00216	45	·01446	78	·09890
13	·00212	46	·01135	79	·13979
14	·00268	47	·01229	80	·12673
15	·00316	48	·01290	81	·12689
16	·00284	49	·01389	82	·13871
17	·00285	50	·01501	83	·15094
18	·00388	51	·01355	84	·17000
19	·00462	52	·01493	85	·17254
20	·00500	53	·01639	86	·15535
21	·00494	54	·01671	87	·19167
22	·00531	55	·01931	88	·19151
23	·00523	56	·01995	89	·27656
24	·00573	57	·02127	90	·26000
25	·00528	58	·02074	91	·22813
26	·00548	59	·02641	92	·33182
27	·00653	60	·02608	93	·35625
28	·00658	61	·02651	94	·26429
29	·00629	62	·03099	95	·41667
30	·00673	63	·03075	96	·27500
31	·00684	64	·03432	97	·40000
32	·00829	65	·03831	98	1·00000

THE GRADUATION OF q_x.

After much experimenting, the formula adopted for graduating the values of q_x below age 20 was

$$q_x = a + bx + cx^2 + df^x \quad . \quad . \quad . \quad . \quad (1)$$

Using the unadjusted data we have

$$0{\cdot}13411 = \sum_0^3 q_x = 4a + 6b + 14c + d \cdot \frac{1-f^4}{1-f}$$

$$0{\cdot}01293 = \sum_7^4 q_x = 4a + 22b + 126c + df^4 \cdot \frac{1-f^4}{1-f}$$

$$0{\cdot}00878=\sum_{8}^{11} q_x = 4a+38b+366c+df^8\cdot\frac{1-f^4}{1-f}$$

$$0{\cdot}01012=\sum_{12}^{15} q_x = 4a+54b+734c+df^{12}\cdot\frac{1-f^4}{1-f}$$

$$0{\cdot}01419=\sum_{16}^{19} q_x = 4a+70b+1230c+df^{16}\cdot\frac{1-f^4}{1-f}$$

On differencing we obtain

$$-0{\cdot}12118=16b+112c-d\cdot\frac{(1-f^4)^2}{1-f}$$

$$-0{\cdot}00415=16b+240c-df^4\cdot\frac{(1-f^4)^2}{1-f}$$

$$+0{\cdot}00134=16b+368c-df^8\cdot\frac{(1-f^4)^2}{1-f}$$

$$+0{\cdot}00407=16b+496c-df^{12}\cdot\frac{(1-f^4)^2}{1-f}$$

Differencing again we have

$$0{\cdot}11703=128c+d\cdot\frac{(1-f^4)^3}{1-f}$$

$$0{\cdot}00549=128c+df^4\cdot\frac{(1-f^4)^3}{1-f}$$

$$0{\cdot}00273=128c+df^8\cdot\frac{(1-f^4)^3}{1-f}$$

Differencing once more

$$0{\cdot}11154=d\cdot\frac{(1-f^4)^4}{1-f}$$

$$0{\cdot}00276=df^4\cdot\frac{(1-f^4)^4}{1-f},$$

whence on division

$$f^4=0{\cdot}0247445,$$

giving

$$f=0{\cdot}396616.$$

We can now easily solve for d, a, b, and c ; and we get

$$\begin{aligned} d &= 0{\cdot}074396 \\ c &= 0{\cdot}00002078 \\ b &= -0{\cdot}000390 \\ a &= 0{\cdot}00398. \end{aligned}$$

Using these constants the values of q_x can be calculated. These fitted the ungraduated values closely up to age 15. They were therefore used as the graduated values up to age 15.

For ages above 20 the following formula was used :—

$$q_{20+x} = A + Bx + CD^x \quad . \quad . \quad . \quad . \quad (2)$$

Using the data we have

$$0{\cdot}11819 = \sum_{0}^{17} q_{20+x} = 18A + 153B + C \cdot \frac{D^{18}-1}{D-1}$$

$$0{\cdot}22821 = \sum_{18}^{35} q_{20+x} = 18A + 477B + CD^{18} \cdot \frac{D^{18}-1}{D-1}$$

$$0{\cdot}71693 = \sum_{36}^{53} q_{20+x} = 18A + 801B + CD^{36} \cdot \frac{D^{18}-1}{D-1}$$

and

$$2{\cdot}75189 = \sum_{54}^{71} q_{20+x} = 18A + 1125B + CD^{54} \cdot \frac{D^{18}-1}{D-1}.$$

The solution of these equations was performed in the same way as in the case of formula (1).

The values found were

$$\begin{aligned} D &= 1{\cdot}081293 \\ C &= 0{\cdot}00105056 \\ B &= -0{\cdot}00003957 \\ A &= 0{\cdot}004689. \end{aligned}$$

It will have been noticed that in finding the latter constants only those values of q_x from age 20 to age 91 were used. The values at the end of the tables were too uncertain to be used.

The values of q_x above age 20 were now calculated and were found to agree fairly well with the ungraduated values from age 24 onwards.

The problem now is to fit a curve which shall have first order contact at age 15 with the curve of formula (1); and at age 24 with the curve of formula (2).

From formula (1) we have at age 15

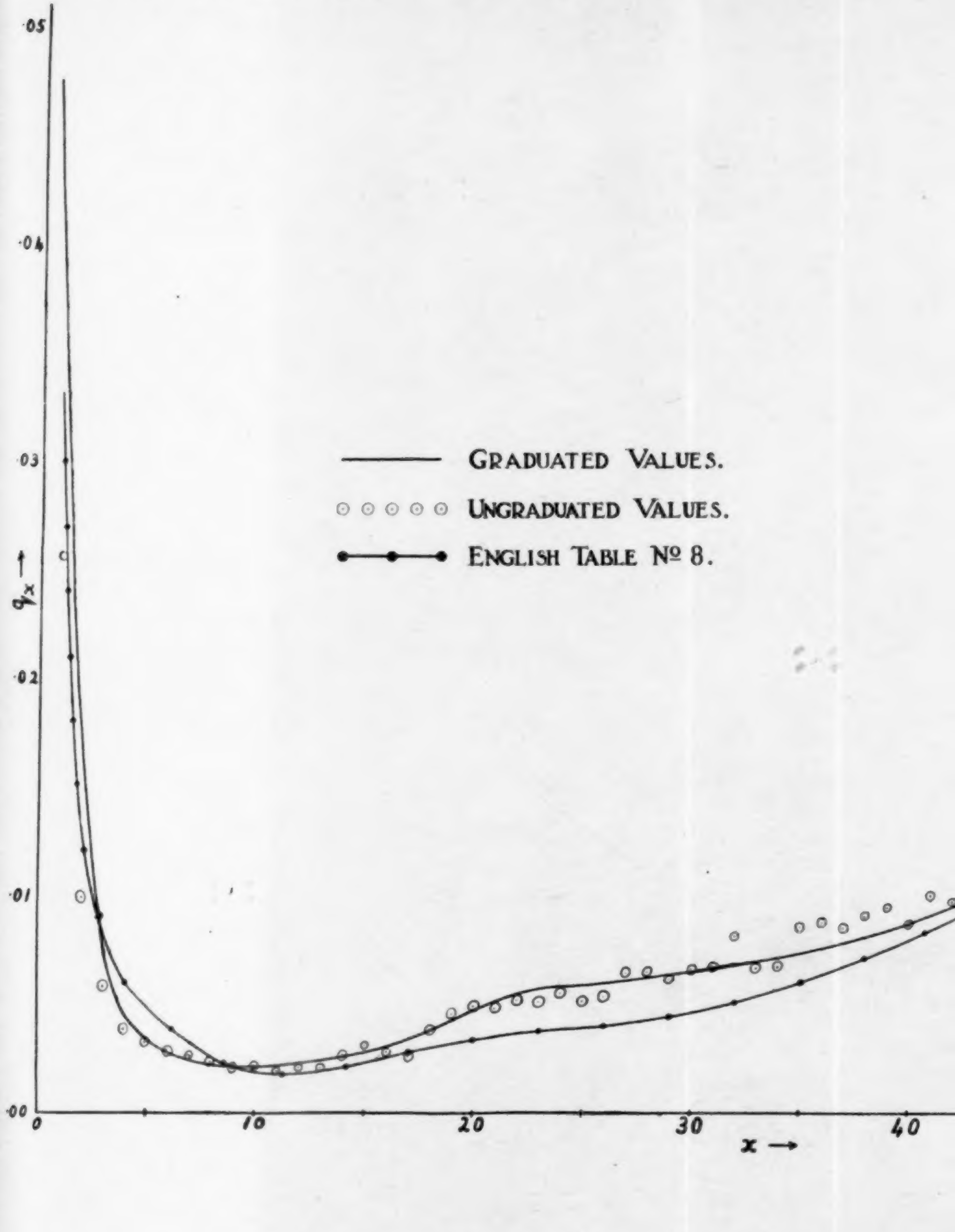
$$q_x = 0{\cdot}00281$$

$$\frac{d}{dx} q_x = 0{\cdot}000233.$$

From formula (2) we have at age 24

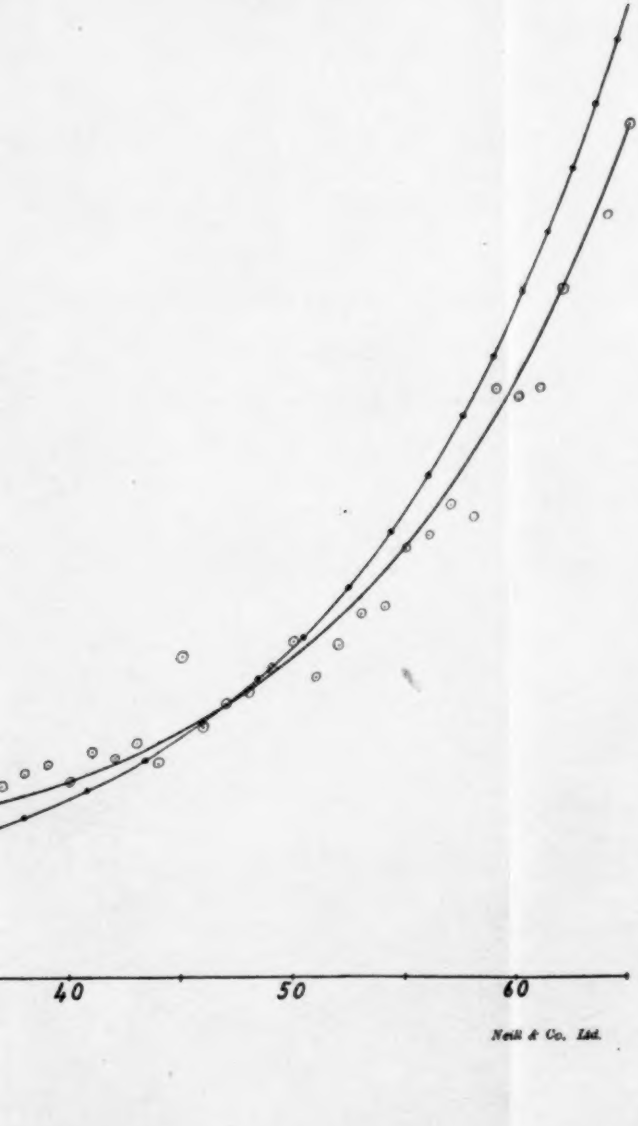
$$q_x = 0{\cdot}00597$$

$$\frac{d}{dx} q_x = 0{\cdot}0000726.$$



·05
·04
·03
·02
·01
·00
q_x ↑
0
10
20
30
40
x →
GRADUATED VALUES.
UNGRADUATED VALUES.
ENGLISH TABLE Nº 8.

Graph I.



Neill & Co. Ltd.

It was assumed that between these ages

$$q_x = p + qx + rx^2 + sx^3 \quad . \quad . \quad . \quad . \quad (3)$$

At age 15:

$$q_x = 0{\cdot}00281 = p + 15q + 225r + 3375s \text{ (from (3))}$$

$$\frac{d}{dx} q_x = 0{\cdot}000233 = q + 30r + 675s \text{ (from (3))}$$

At age 24:

$$q_x = 0{\cdot}00597 = p + 24q + 576r + 13824s \text{ (from (3))}$$

$$\frac{d}{dx} q_x = 0{\cdot}0000726 = q + 48r + 1728s \text{ (from (3))}.$$

These equations are easily solved and give

$$\begin{aligned} p &= 0{\cdot}028707 \\ q &= -0{\cdot}0047876 \\ r &= 0{\cdot}00027752 \\ s &= -0{\cdot}0000048963. \end{aligned}$$

Formula (3) was then used to give the values of q_x between ages 15 and 24.

It will be observed that the ungraduated values of q_x between ages 15 and 24 were not directly employed in finding the constants for formula (3); but were partly employed for finding those for formula (1) and also partly for those for formula (2). These formulæ were then used to find the constants in formula (3).

In the final table we have therefore used

formula (1) for ages 0 to 15,
formula (3) for ages 16 to 24, and
formula (2) for ages above 24.

Table A gives in the first column the age (x), in the second column the graduated values of q_x, and in the third column the ungraduated values of q_x. The last column gives the differences between the graduated and the ungraduated values. Up to age 91 (the last ungraduated value used) the total of the positive deviations is 0·17151 and the total of the negative deviations is 0·17235, so that the total of all the deviations is only $-0{\cdot}00084$.

The graph (I) shows the graduated and ungraduated values plotted together. The continuous line connects the graduated values. The broken line shows the values of q_x taken from English Life Tables No. 8, males. The graph shows that the English table gives a higher rate of mortality up to age 9, then a lower rate up to age 46, after which it is again higher than the South African rate.

TABLE A.

Age.	q_x Graduated.	q_x Un-graduated.	Difference.	Age.	q_x Graduated.	q_x Un-graduated.	Difference.
0	0·07838	0·09318	−1480	48	0·01295	0·01290	+ 5
1	·03312	·02556	+ 756	49	·01368	·01389	− 21
2	·01499	·00954	+ 545	50	·01446	·01501	− 55
3	·00764	·00583	+ 181	51	·01531	·01355	+ 176
4	·00459	·00390	+ 69	52	·01624	·01493	+ 131
5	·00328	·00344	− 16	53	·01724	·01639	+ 85
6	·00268	·00290	− 22	54	·01832	·01671	+ 161
7	·00238	·00269	− 31	55	·01950	·01931	+ 19
8	·00224	·00241	− 17	56	·02078	·01995	+ 83
9	·00217	·00212	+ 5	57	·02216	·02127	+ 89
10	·00217	·00226	− 9	58	·02366	·02074	+ 292
11	·00221	·00199	+ 22	59	·02529	·02641	− 112
12	·00229	·00216	+ 13	60	·02705	·02608	+ 97
13	·00242	·00212	+ 30	61	·02896	·02651	+ 245
14	·00259	·00268	− 9	62	·03102	·03099	+ 3
15	·00281	·00316	− 35	63	·03326	·03075	+ 251
16	·00310	·00284	+ 36	64	·03568	·03432	+ 136
17	·00346	·00285	+ 61	65	·03830	·03831	− 1
18	·00389	·00388	+ 1	66	·04114	·03846	+ 268
19	·00434	·00462	− 28	67	·04421	·04621	− 200
20	·00479	·00500	− 21	68	·04753	·04291	+ 462
21	·00521	·00494	+ 27	69	·05113	·05628	− 515
22	·00556	·00531	+ 25	70	·05503	·05444	+ 59
23	·00583	·00523	+ 60	71	·05924	·06565	− 641
24	·00597	·00573	+ 24	72	·06380	·06900	− 514
25	·00604	·00528	+ 76	73	·06873	·06865	+ 8
26	·00613	·00548	+ 65	74	·07407	·07951	− 544
27	·00623	·00653	− 30	75	·07984	·07913	+ 71
28	·00634	·00658	− 24	76	·08609	·08829	− 220
29	·00646	·00629	+ 17	77	·09285	·07724	+1561
30	·00659	·00673	− 14	78	·10016	·09890	+ 126
31	·00674	·00684	− 10	79	·10806	·13979	−3173
32	·00690	·00829	− 139	80	·11662	·12673	−1011
33	·00708	·00679	+ 29	81	·12587	·12689	− 102
34	·00727	·00682	+ 45	82	·13588	·13871	− 283
35	·00749	·00873	− 124	83	·14670	·15094	− 424
36	·00772	·00896	− 124	84	·15841	·17000	−1159
37	·00798	·00866	− 68	85	·17107	·17254	− 147
38	·00827	·00922	− 95	86	·18477	·15535	+2942
39	·00858	·00969	− 111	87	·19958	·19167	+ 791
40	·00891	·00792	+ 99	88	·21560	·19151	+2409
41	·00928	·01025	− 97	89	·23293	·27656	−4363
42	·00968	·00995	− 27	90	·25166	·26000	− 834
43	·01012	·01063	− 51	91	·27192	·22813	+4379
44	·01060	·00976	+ 84				−0·17235
45	·01111	·01446	− 335				+0·17151
46	·01168	·01135	+ 33				−0·00084
47	·01229	·01229	0				

In Table B we have the complete life table giving the number living at exact age $x = l_x (l_0 = 1000000)$; number dying aged $x = d_x$; probability that a person aged x will be alive at the end of one year $= p_x$; probability that a person aged x will die within one year $= q_x$; population aged $x = \mathrm{L}_x$; population aged x and upwards $= \mathrm{T}_x$; and the complete expectation of life $\mathring{e}_x = \dfrac{\mathrm{T}_x}{l_x}$.

The following table gives the values of $\mathring{e}_x$ taken from this 1918–1921 Census Table and various other tables.

Column (2) S.A. Mutual Table was constructed by Mr. Gordon from the experience of the office from 1845 to 1895.

Column (3) was based upon the estimated population of England and Wales on 30th June 1909, and deaths registered during the three years 1908–1910.

Column (4) was constructed by Dr. Maynard from a census of the Johannesburg population *circa* 1910.

Column (5) gives the experience of the Australian Mutual Provident Society during the years 1849 to 1903.

Column (6) is from an American Mortality Table, kindly lent by the manager of the Johannesburg office of the Sun Life Office of Canada.

Columns (7) and (8) are from the well-known $\mathrm{H^M}$ (Text-book) Table and English Life Table No. 8.

Column (9) is from Scottish Life Tables, 1921.

Age.	(1) S.A. Census Table.	(2) S.A. Mutual Table.	(3) England and Wales Table.	(4) Johannesburg Table.	(5) A.M.P.S. Table.	(6) American Table.	(7) $\mathrm{H^M}$ Table.	(8) English No. 8 Table.	(9) Scottish Life Table.
0	53·85	..	..	50·83	..	..	47·78	51·50	53·08
5	56·92	..	..	56·50	..	..	53·40	57·14	..
10	52·62	..	..	52·52	..	48·72	50·26	53·08	53·55
20	44·02	42·69	43·68	43·68	47·38	42·20	42·10	44·21	44·82
30	36·37	34·46	35·29	35·71	38·88	35·33	34·73	35·81	36·52
40	28·80	26·83	27·27	28·31	30·64	28·18	27·39	27·74	28·43
50	21·55	19·63	19·85	21·71	22·79	20·91	20·27	20·29	20·68
60	15·04	13·56	13·38	15·63	15·55	14·10	13·81	13·78	13·82
70	9·63	8·22	8·25	9·99	9·78	8·48	8·49	8·53	8·40
80	5·58	5·80	4·64	5·59	5·34	4·39	4·66	4·90	4·78

TABLE B.

Age.	l_x.	d_x.	p_x.	q_x.	L_x.	T_x.	$\overset{\circ}{e}_x$.
0	1000000	78380	·92162	0·07838	960810	53847423	53·85
1	921620	30524	·96688	·03312	906358	52886613	57·38
2	891096	13358	·98501	·01499	884417	51980255	58·33
3	877738	6706	·99236	·00764	874385	51095838	58·21
4	871032	3998	·99541	·00459	869033	50221453	57·66
5	867034	2844	·99672	·00328	865612	49352420	56·92
6	864190	2316	·99732	·00268	863032	48486808	56·11
7	861874	2051	·99762	·00238	860848	47623776	55·26
8	859823	1926	·99776	·00224	858860	46762928	54·39
9	857897	1862	·99783	·00217	856966	45904068	53·51
10	856035	1858	·99783	·00217	855106	45047102	52·62
11	854177	1888	·99779	·00221	853233	44191996	51·74
12	852289	1952	·99771	·00229	851313	43338763	50·85
13	850337	2058	·99758	·00242	849308	42487450	49·96
14	848279	2197	·99741	·00259	847180	41638142	49·08
15	846082	2377	·99719	·00281	844893	40790962	48·21
16	843705	2615	·99690	·00310	842397	39946069	47·35
17	841090	2910	·99654	·00346	839635	39103672	46·49
18	838180	3261	·99611	·00389	836550	38264037	45·65
19	834919	3624	·99566	·00434	833107	37427487	44·83
20	831295	3982	·99521	·00479	829304	36594380	44·02
21	827313	4310	·99479	·00521	825158	35765076	43·23
22	823003	4576	·99444	·00556	820715	34939418	42·45
23	818427	4771	·99417	·00583	816042	34119203	41·69
24	813656	4858	·99403	·00597	811227	33303161	40·93
25	808798	4885	·99396	·00604	806356	32491934	40·17
26	803913	4928	·99387	·00613	801449	31685578	39·41
27	798985	4978	·99377	·00623	796496	30884129	38·65
28	794007	5034	·99366	·00634	791490	30087633	37·89
29	788973	5097	·99354	·00646	786425	29296143	37·13
30	783876	5166	·99341	·00659	781293	28509718	36·37
31	778710	5249	·99326	·00674	776086	27728425	35·61
32	773461	5337	·99310	·00690	770793	26952339	34·85
33	768124	5438	·99292	·00708	765405	26181546	34·08
34	762686	5545	·99273	·00727	759914	25416141	33·32
35	757141	5671	·99251	·00749	754306	24656227	32·56
36	751470	5801	·99228	·00772	748570	23901921	31·81
37	745669	5950	·99202	·00798	742694	23153351	31·05
38	739719	6117	·99173	·00827	736661	22410657	30·30
39	733602	6302	·99142	·00858	730451	21673996	29·54
40	727300	6480	·99109	·00891	724060	20943545	28·80
41	720820	6689	·99072	·00928	717476	20219485	28·05
42	714131	6913	·99032	·00968	710675	19502009	27·31
43	707218	7157	·98988	·01012	703640	18791334	26·57
44	700061	7421	·98940	·01060	696355	18087694	25·84
45	692640	7695	·98889	·01111	688793	17391339	25·11
46	684945	8000	·98832	·01168	680945	16702546	24·38
47	676945	8320	·98771	·01229	672785	16021601	23·67
48	668625	8659	·98705	·01295	664296	15348816	22·96
49	659966	9028	·98632	·01368	655452	14684520	22·25
50	650938	9413	·98554	·01446	646232	14029068	21·55
51	641525	9822	·98469	·01531	636614	13382836	20·86
52	631703	10259	·98376	·01624	626574	12746222	20·18
53	621444	10714	·98276	·01724	616087	12119648	19·50

TABLE B.—(*continued*).

Age.	l_x.	d_x.	p_x.	q_x.	L_x.	T_x.	$\overset{\circ}{e}_x$.
54	610730	11189	·98168	·01832	605136	11503561	18·83
55	599541	11691	·98050	·01950	593696	10898425	18·18
56	587850	12216	·97922	·02078	581742	10304729	17·53
57	575634	12756	·97784	·02216	569256	9722987	16·89
58	562878	13318	·97634	·02366	556219	9153731	16·26
59	549560	13898	·97471	·02529	542611	8597512	15·64
60	535662	14490	·97295	·02705	528417	8054901	15·04
61	521172	15093	·97104	·02896	513626	7526484	14·44
62	506079	15699	·96898	·03102	498230	7012858	13·86
63	490380	16310	·96674	·03326	482225	6514628	13·28
64	474070	16915	·96432	·03568	465613	6032403	12·72
65	457155	17509	·96170	·03830	448401	5566790	12·18
66	439646	18087	·95886	·04114	430603	5118389	11·64
67	421559	18637	·95579	·04421	412241	4687786	11·12
68	402922	19151	·95247	·04753	393347	4275545	10·61
69	383771	19622	·94887	·05113	373960	3882198	10·11
70	364149	20039	·94497	·05503	354130	3508238	9·63
71	344110	20385	·94076	·05924	333918	3154108	9·16
72	323725	20654	·93620	·06380	313398	2820190	8·71
73	303071	20830	·93127	·06873	292656	2506792	8·27
74	282241	20906	·92593	·07407	271788	2214136	7·84
75	261335	20865	·92016	·07984	250903	1942348	7·43
76	240470	20702	·91391	·08609	230119	1691445	7·03
77	219768	20405	·90715	·09285	209566	1461326	6·65
78	199363	19968	·89984	·10016	189379	1251760	6·28
79	179395	19385	·89194	·10806	169703	1062381	5·92
80	160010	18660	·88338	·11662	150680	893178	5·58
81	141350	17792	·87413	·12587	132454	741998	5·25
82	123558	16789	·86412	·13588	115164	609544	4·93
83	106769	15663	·85330	·14670	98938	494380	4·63
84	91106	14432	·84159	·15841	83890	395442	4·34
85	76674	13117	·82893	·17107	70116	311552	4·06
86	63557	11743	·81523	·18477	57686	241436	3·80
87	51814	10341	·80042	·19958	46644	183750	3·55
88	41473	8942	·78440	·21560	37002	137106	3·31
89	32531	7577	·76707	·23293	28743	100104	3·08
90	24954	6280	·74834	·25166	21814	71361	2·86
91	18674	5078	·72808	·27192	16135	49547	2·65
92	13596	3995	·70616	·29384	11599	33412	2·46
93	9601	3049	·68246	·31754	8077	21813	2·27
94	6552	2248	·65684	·34316	5428	13736	2·10
95	4304	1596	·62912	·37088	3506	8308	1·93
96	2708	1086	·59915	·40085	2165	4802	1·77
97	1622	702·7	·56674	·43326	1270·7	2637	1·63
98	919·3	430·5	·53169	·46831	704·1	1366·5	1·49
99	488·8	247·4	·49380	·50620	365·1	662·4	1·36
100	241·4	132·1	·45281	·54719	175·4	297·3	1·23
101	109·3	64·65	·40849	·59151	76·98	121·92	1·12
102	44·65	28·55	·36057	·63943	30·38	44·94	1·01
103	16·10	11·13	·30874	·69126	10·54	14·56	0·90
104	4·971	3·715	·25270	·74730	3·114	4·016	·81
105	1·256	1·015	·19210	·80790	0·7487	0·9016	·72
106	0·2413	0·2108	·12657	·87343	·1359	·1529	·63
107	·0305	·0288	·05571	·94429	·0161	·0170	·56
108	·0017	·0017	·00000	1·00000	·0009	·0009	·53

GRADUATION BY MAKEHAM'S LAW.

Makeham's formula for the number living aged x is

$$l_x = ks^x g^{c^x} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

whence

$$p_x = \frac{l_{x+1}}{l_x} = sg^{c^x(c-1)}$$

i.e.

$$\log p_x = \log s + c^x(c-1) \log g \quad . \quad . \quad . \quad . \quad (5)$$

and

$$\sum_{a}^{b-1} \log p_x = (b-a) \log s + c^a(c^{b-a}-1) \log g.$$

Using the ungraduated values of p_x (found by subtracting the ungraduated values of q_x from unity) we have

$$-0{\cdot}0766598 = \sum_{20}^{43} \log p_x = 24 \log s + c^{20}(c^{24}-1) \log g,$$

$$-0{\cdot}2335237 = \sum_{44}^{67} \log p_x = 24 \log s + c^{44}(c^{24}-1) \log g,$$

$$-1{\cdot}4779722 = \sum_{68}^{91} \log p_x = 24 \log s + c^{68}(c^{24}-1) \log g.$$

Differencing we have

$$-0{\cdot}1568639 = c^{20}(c^{24}-1)^2 \log g,$$

and

$$-1{\cdot}2444485 = c^{44}(c^{24}-1)^2 \log g\,;$$

whence on division

$$c^{24} = \frac{12444485}{1568639} = 7{\cdot}9333008,$$

giving

$$c = 1{\cdot}090127 \quad \therefore \log c = 0{\cdot}0374772$$
$$\log g = \bar{1}{\cdot}9994191$$
$$\log s = \bar{1}{\cdot}9977485.$$

Now

$$\log l_x = \log k + x \log s + c^x \log g \quad . \quad . \quad . \quad . \quad (6)$$

I have taken $l_{20} = 831295$, given by the previous graduation, so as to obtain figures in the two tables of the same order of magnitude.

Using this value for l_{20} in (6) we get

$$\log k = 5{\cdot}9197552,$$

log. p_x is now easily found for all values of x and also log l_x; whence we get p_x and l_x.

In Table C we have again compared the graduated and ungraduated values of p_x; and the net deviation is $+0{\cdot}00396$. A comparison of the figures in Table C shows a close agreement.

Makeham's law, of course, does not apply at all ages.

In Table D we have the complete life table again, N'_x being the sum of l_{x+1}, l_{x+2}, and so on to the end of the table.

Graph II shows a comparison of the values of $\mathring{e}_x$ from this table with those from the H^M Table (text-book graduation).

It will be observed that there is a slowly decreasing difference between the values of $\mathring{e}_x$. The differences are shown in the following table :—

Age.	$\mathring{e}_x$ S.A.	$\mathring{e}_x$ H^M.	Difference.
20	44·01	42·10	1·91
25	40·27	38·38	1·89
30	36·50	34·73	1·77
35	32·73	31·05	1·68
40	28·99	27·39	1·60
45	25·30	23·78	1·52
50	21·73	20·27	1·46
55	18·33	16·93	1·40
60	15·13	13·81	1·32
65	12·22	10·98	1·24
70	9·63	8·49	1·14
75	7·40	6·38	1·02
80	5·54	4·66	0·88

The following is a comparison of the values of the constants used in the S.A. Table and those used in the H^M Table.

Constant.	S.A. Table.	H^M Table.
c	1·090127	1·095612
g	0·998663	0·998949
s	0·994829	0·993827
log c	0·0374772	0·0396569
log g	$\bar{1}$·9994191	$\bar{1}$·9995432
log s	$\bar{1}$·9977485	$\bar{1}$·9973107

TABLE C.

Age.	p_x Graduated.	p_x Un-graduated.	Difference.	Age.	p_x Graduated.	p_x Un-graduated.	Difference.
20	99416	99500	− 84	56	98012	98005	+ 7
21	99410	99506	− 96	57	97855	97873	− 18
22	99403	99469	− 66	58	97710	97926	− 216
23	99396	99477	− 81	59	97552	97359	+ 193
24	99388	99427	− 39	60	97380	97392	− 12
25	99379	99472	− 93	61	97192	97349	− 157
26	99370	99452	− 82	62	96988	96901	+ 87
27	99360	99347	+ 13	63	96767	96925	− 158
28	99349	99342	+ 7	64	96526	96568	− 42
29	99337	99371	− 34	65	96263	96169	+ 94
30	99323	99327	− 4	66	95978	96154	− 176
31	99309	99316	− 7	67	95669	95379	+ 290
32	99294	99171	+ 123	68	95332	95309	+ 23
33	99276	99323	− 47	69	94967	94372	+ 595
34	99258	99318	− 60	70	94569	94556	+ 13
35	99237	99127	+ 110	71	94139	93435	+ 704
36	99215	99104	+ 111	72	93672	93100	+ 572
37	99191	99134	+ 57	73	93165	93135	+ 30
38	99165	99078	+ 87	74	92616	92049	+ 567
39	99136	99031	+ 105	75	92021	92087	− 66
40	99105	99208	− 103	76	91376	91171	+ 205
41	99071	98975	+ 96	77	90679	92276	−1597
42	99034	99005	+ 29	78	89925	90110	− 185
43	98994	98937	+ 57	79	89110	86021	+3089
44	98950	99024	− 74	80	88230	87327	+ 903
45	98902	98554	+ 348	81	87280	87311	− 31
46	98850	98865	− 15	82	86257	86129	+ 128
47	98793	98771	+ 22	83	85155	84906	+ 249
48	98731	98710	+ 21	84	83970	83000	+ 970
49	98664	98611	+ 53	85	82696	82746	− 50
50	98590	98499	+ 91	86	81330	84465	−3135
51	98510	98645	− 135	87	79867	80833	− 966
52	98423	98507	− 84	88	78302	80849	−2547
53	98328	98361	− 33	89	76630	72344	+4286
54	98224	98329	− 105	90	74849	74000	+ 849
55	98112	98069	+ 43	91	72954	77187	−4233
							Total + = 0·15227
							Total − = 0·14831
							Net total = +0·00396


S.A. TABLE
H^{M} TABLE
45
40
35
30
25
20
15
10
5
20
30
40
50
60
70
80
90
100
x

GRAPH II.

TABLE D.

Age.	l_x.	d_x.	p_x.	q_x.	N'_x.	$\mathring{e}_x$.
20	831295	4858	·99416	·00584	36166639	44·01
21	826437	4880	·99410	·00590	35340202	43·26
22	821557	4906	·99403	·00597	34518645	42·52
23	816651	4935	·99396	·00604	33701994	41·77
24	811716	4969	·99388	·00612	32890278	41·02
25	806747	5007	·99379	·00621	32083531	40·27
26	801740	5052	·99370	·00630	31281791	39·52
27	796688	5100	·99360	·00640	30485103	38·76
28	701588	5156	·99349	·00651	29693515	38·01
29	786432	5218	·99337	·00663	28907083	37·26
30	781214	5286	·99323	·00677	28125869	36·50
31	775928	5362	·99309	·00691	27349941	35·75
32	770566	5442	·99294	·00706	26579375	34·99
33	765124	5537	·99276	·00724	25814251	34·24
34	759587	5638	·99258	·00742	25054664	33·48
35	753949	5750	·99237	·00763	24300715	32·73
36	748199	5871	·99215	·00785	23552516	31·98
37	742328	6004	·99191	·00809	22810188	31·23
38	736324	6148	·99165	·00835	22073864	30·48
39	730176	6306	·99136	·00864	21343688	29·73
40	723870	6577	·99105	·00895	20619818	28·99
41	717393	6663	·99071	·00929	19902425	28·24
42	710730	6864	·99034	·00966	19191695	27·50
43	703866	7082	·98994	·01006	18487829	26·77
44	696784	7317	·98950	·01050	17791045	26·03
45	689467	7570	·98902	·01098	17101578	25·30
46	681897	7843	·98850	·01150	16419681	24·58
47	674054	8137	·98793	·01207	15745627	23·86
48	665917	8450	·98731	·01269	15079710	23·15
49	657467	8787	·98664	·01336	14422243	22·44
50	648680	9146	·98590	·01410	13773563	21·73
51	639534	9530	·98510	·01490	13134029	21·04
52	630004	9937	·98423	·01577	12504025	20·35
53	620067	10369	·98328	·01672	11883958	19·67
54	609698	10817	·98224	·01776	11274260	18·99
55	598871	11309	·98112	·01888	10675389	18·33
56	587562	11684	·98012	·01988	10087827	17·67
57	575878	12350	·97855	·02145	9511949	17·02
58	563528	12905	·97710	·02290	8948421	16·37
59	550623	13480	·97552	·02448	8397798	15·75
60	537143	14075	·97380	·02620	7860655	15·13
61	523068	14687	·97192	·02808	7337587	14·53
62	508381	15311	·96988	·03012	6829206	13·93
63	493070	15943	·96767	·03233	6336136	13·35
64	477127	16578	·96526	·03474	5859009	12·78

TABLE D.—(*continued*).

Age.	l_x.	d_x.	p_x.	q_x.	N'_x.	$\overset{\circ}{e}_x$.
65	460549	17209	·96263	·03737	5398460	12·22
66	443340	17830	·95978	·04022	4955120	11·68
67	425510	18431	·95669	·04331	4529610	11·15
68	407079	19002	·95332	·04668	4122531	10·63
69	388077	19534	·94967	·05033	3734454	10·12
70	368543	20014	·94569	·05431	3365911	9·63
71	348529	20427	·94139	·05861	3017382	9·16
72	328102	20763	·93672	·06328	2689280	8·70
73	307339	21007	·93165	·06835	2381941	8·25
74	286332	21144	·92616	·07384	2095609	7·82
75	265188	21161	·92021	·07979	1830421	7·40
76	244027	21045	·91376	·08624	1586394	7·00
77	222982	20785	·90679	·09321	1363412	6·61
78	202197	20372	·89925	·10075	1161215	6·24
79	181825	19802	·89110	·10890	979390	5·88
80	162023	19071	·88230	·11770	817367	5·54
81	142952	18183	·87280	·12720	674415	5·22
82	124769	17147	·86257	·13743	549646	4·91
83	107622	15977	·85155	·14845	442024	4·61
84	91645	14691	·83970	·16030	350379	4·32
85	76954	13316	·82696	·17304	273425	4·05
86	63638	11881	·81330	·18670	209787	3·80
87	51757	10420	·79867	·20133	158030	3·55
88	41337	8970	·78302	·21698	116693	3·32
89	32367	7564	·76630	·23370	84326	3·11
90	24803	6238	·74849	·25151	59523	2·90
91	18565	5021	·72954	·27046	40958	2·71
92	13544	3936	·70943	·29057	27414	2·52
93	9608	2992	·68813	·31187	17806	2·35
94	6616	2212	·66565	·33435	11190	2·19
95	4404	1577	·64197	·35803	6786	2·04
96	2827	1082	·61712	·38288	3959	1·90
97	1745	713·5	·59113	·40887	2214	1·77
98	1031·5	449·7	·56404	·43596	1183	1·65
99	581·8	270·0	·53592	·46408	600·8	1·53
100	311·8	153·8	·50685	·49315	289·0	1·43
101	158·0	82·64	·47697	·52303	131·0	1·33
102	75·36	41·72	·44639	·55361	55·69	1·24
103	33·64	19·67	·41529	·58471	22·05	1·18
104	13·97	8·608	·38384	·61616	8·078	1·08
105	5·362	3·473	·35227	·64773	2·716	1·01
106	1·889	1·1283	·32081	·67919	0·8271	0·94
107	0·6060	0·4304	·28970	·71030	0·2211	0·86
108	0·1756	0·1301	·25921	·74079	0·0455	0·76
109	0·0455	0·0455	·22962	·77038		0·50

* It will be noticed that the value of log c is considerably lower for the S.A. Table.

For the Seventeen Offices Table log c	=0·03956
H^{MF}	=0·04000
Thirty American Offices	=0·04128
Gotha Life Office	=0·03963
$O^{[M]}$	=0·039
H^{M}	=0·03966
S.A. Table	=0·03748.

This shows that our value of log c is very much lower than the average of the other values.

In conclusion, I should like to thank Mr. C. Cousins of the Census Department for placing data at my disposal, and also Professor J. P. Dalton of this University for his invaluable advice and encouragement.

* See Robertson and Ross, Actuarial Theory, p. 117.

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TRANSACTIONS

OF THE

ROYAL SOCIETY OF SOUTH AFRICA.

VOL. XII.

MINUTES OF PROCEEDINGS.

Anniversary Meeting.

The Anniversary Meeting of the Society was held on Wednesday, March 15, 1916, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. L. Péringuey, was in the Chair.

The Report of the Hon. General Secretary was submitted and adopted.

The Report of the Hon. Treasurer was submitted and adopted.

The following were elected Members of the Council for the year 1916:—

Dr. J. C. Beattie.
Dr. G. S. Corstorphine.
Dr. L. Crawford.
Dr. J. K. E. Halm.
Dr. W. A. Jolly.
Dr. C. F. Juritz.
Mr. C. P. Lounsbury.
Dr. L. Péringuey.
Dr. B. St. J. v. d. Riet.
Dr. S. Schönland.
Sir A. Theiler.
Dr. A. Marius Wilson.

Dr. L. Péringuey, was elected President.
Dr. L. Crawford, Hon. Treasurer.
Dr. W. A. Jolly, Hon. General Secretary.

Report of the Hon. General Secretary for the Year ending December 31, 1915.

Seven Ordinary Meetings, the Annual and the Anniversary Meetings, were held during the year and the following papers were read:—

"The Bushman as a Palaeolithic Man," by L. Péringuey (Presidential Address).

"Some Notes on the South African Erysiphaceae," by ETHEL M. DOIDGE.

"Geitsi Gubib, an old Volcano," by A. W. ROGERS.

"The Equivalent Mass of a Spring vibrating longitudinally," by ALEXANDER BROWN.

"The Occurrence of Dinosaur Bones in Bushmanland," by A. W. ROGERS.

"Description of the Dinosaur Bones from Bushmanland," by S. H. HAUGHTON.

"The Coccidae of South Africa," by CHAS. K. BRAIN.

"A Note on the Molecules of Liquid Crystals," by J. S. v. D. LINGEN.

"On the 'Lines' within Röntgen Interference Photographs," by J. S. v. D. LINGEN.

"Osteology of Palaeornis, with other Notes on the Genus," by R. W. SHUFELDT.

"Note on Apparent Apogamy in Pterygodium Newdigatae," by Miss A. V. DUTHIE.

"A Record of Plants collected in Southern Rhodesia," by FRED EYLES.

"Description of : (1) a Simple Apparatus for finding 'g'; (2) a Simple Apparatus for standarising a given Vibrator," by J. S. v. D. LINGEN.

"Description of a New Type of Fossil Reptile from the Karroo," by S. H. HAUGHTON.

"The Electromotive Changes accompanying Activity in the Mammalian Ureter," by W. A. JOLLY.

"A New Aloe from Swaziland," by I. B. POLE-EVANS.

"The Growth Forms of Natal Plants," by J. W. BEWS.

"The South African Rust Fungi : I. The Species of Puccinia on Compositae." by I. B. POLE-EVANS.

"Heating and Cooling Apparatus for Röntgen Crystallographic Work," by J. S. v. D. LINGEN.

"South African Perisporiales : I. Perisporiaceae," by ETHEL M. DOIDGE.

"The Arrangement of Successive Convergents in Order of Accuracy," by ALEXANDER BROWN.

"The Use of a Standard Parabola for Drawing Diagrams of Bending Moment and of Shear in a Beam uniformly loaded," by ALEXANDER BROWN.

"Description of a South African Species of Pelodrilus," by E. J. GODDARD and C. S. GROBBELAAR.

"Note on Ancient Human Skull Remains from the Transvaal," by S. H. HAUGHTON.

"The Elastic Arch continuous over Several Spans, capable only of Small Rotary Motions at the Supports," by A. N. Henderson.

"The Heating Co-efficients of Rheostats and the Calculation of Resistances for Currents of Short and Moderate Duration," by H. Bohle.

"Further Magnetic Observations in South Africa during the Years 1914–15," by J. C. Beattie.

"True Isogonics and Isoclinals for South Africa for the Epoch July 1, 1913," by J. C. Beattie.

"Descriptions of Some New Aloes from the Transvaal," by I. B. Pole-Evans.

"A New Harmonic Analyser," by J. T. Morrison.

The Society decided, in view of the reduction for the year of the financial contribution from the Government, not to award research grants in 1915.

During the past year further progress has been made with the cataloguing of the Society's library.

The publications of the undermentioned Societies have been examined and catalogued, and communications are proceeding with the Societies regarding filling up of blanks.

Smithsonian Institution (Reports, Bulletins, Miscellaneous Contributions, Reprints from Proceedings, Contributions from U.S. National Herbarium, U.S. National Museum—Proceedings).

Wisconsin Academy of Science (Transactions).

Washington University (Studies).

National Academy of Sciences (Proceedings).

U.S. Dept. of Agriculture (Weather Bureau Reports).

Bureau of Science, Manila (The Philippine Journal of Science—Section A., Chem. and Geol. Sci. etc.; Section B., Tropical Medicine; Section C., Botany; Section D., Gen. Biological Sci.; Bulletin of Philippine Library).

Royal Canadian Institute (Transactions).

Royal Society of Canada (Proceedings and Transactions).

Nova Scotian Institute of Science (Proceedings and Transactions).

Canada: Geological Survey (Reports, Memoirs, Museum Bulletins).

The Canadian Record of Science.

Additional library accommodation has become urgently necessary.

Vol. IV., part 3, and Vol. V., parts 1, 2, and 3 of the Society's Transactions have been issued during the year.

The number of Honorary Fellows is 4; Fellows, 50; Members, 167.

The Society regrets to have to record the death, since the 1915 Anniversary Meeting, of H. Kynaston and J. Medley Wood, Fellows; and W. Fletcher and W. W. Stoney, Members.

TREASURER'S ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1915.

Receipts.

	£	s.	d.	£	s.	d.
To Balance in Bank as per Pass Book				116	17	2
,, Subscriptions received in 1915 :						
for 1913, 2 Fellows at £2, 3 Town Members at £2, 3 Country Members at £1	13	0	0			
for 1914, 4 Fellows at £2, balance £4 of subscription of Country Member elected Fellow, 6 Town Members at £2, 15 Country Members at £1	36	0	0			
for 1915, 43 Fellows at £2, balance 1 Fellow £1, 18s., 51 Town Members at £2, 83 Country Members at £1, part 1 Country Member 4s.	273	2	0			
for 1916, part 1 Fellow 4s., part 2 Town Members 4s., 1 Country Member £1, part 2 Country Members 3s...	1	11	0			
				323	13	0
,, Entrance Fees received, 9 new Members ..				9	0	0
,, Sale of Publications to Government				100	0	0
,, Sale of Publications otherwise				12	5	4
,, Sales of Reprints of Papers				4	1	0
,, Interest on Fixed Deposit in Standard Bank, 1914–15				32	0	0
				£597	16	6

Expenditure.

	£	s.	d.
By Publications	237	13	8
,, Landing Charges, etc.	3	10	4
,, Research Grant, less refunds	65	0	0
,, Cost of Stamps on retaining £800 for one year on Fixed Deposit, Standard Bank	0	4	0
,, Payments in connection with Grant to Professor Pearson for Botanical Exploration in Namaqualand	13	9	3
,, Compilation for International Scientific Catalogue of Papers	25	0	0
,, Clerical Assistance and Work in Library	55	0	0
,, Local Printing and Stationery	25	14	0
,, Blackboard for Meetings	4	0	0
,, Postages and Petties	35	0	0
,, Bank Charges for Commissions, Ledger Fee, Deposit Book, Cheque Book, less Commissions paid by Members	2	1	6
,, Hire of Rooms for Meetings and Caretaker, 1915	5	15	6
,, Cash, Entrance Fees received 1915, put into Post Office Savings Bank	9	0	0
,, Balance in Bank as per Pass Book	116	8	3
	£597	16	6

ASSETS AND LIABILITIES AS AT DECEMBER 31, 1915.

Assets.

	£	s.	d.
Money at Standard Bank on Fixed Deposit at 4 per cent...	800	0	0
Money in Post Office Savings Bank, Life Subscriptions and Entrance Fees	134	0	0
Money in Post Office Savings Bank, at call, with Interest to 31st March 1915..	415	3	2
Balance in Standard Bank, as per Pass Book	116	8	3
Petty Cash in hands of Hon. Secretary	1	6	6
Arrears of Subscriptions, as in Statement for 1914, due at beginning of 1915, £83, less £49 paid in year and £23 struck off as irrecoverable	11	0	0
Arrears of 1915 Subscriptions	44	15	0
Money due for Sale of Reprints of Papers	3	3	0
	£1525	15	11

Liabilities.

	£	s.	d.
Subscriptions, whole or in part, received for 1916	1	11	0
Balance Grant to Professor Pearson for Botanical Exploration in Namaqualand	44	6	3
Research Grant voted in 1914 to Miss M. Wilman	50	0	0
Earmarked for Expense of Publishing, as a part of the Transactions, a reproduction of a Bushman Painting (Council Minutes, May 12, 1915), a sum not exceeding..	350	0	0
Balance from 1912 Conversazione carried forward towards the expenses of future Conversazione in Cape Town ..	7	4	0
	£453	1	3

We have audited the accounts and checked the vouchers of the Royal Society of South Africa for the year 1915, and find the same, to the best of our belief, correct.

J. C. BEATTIE.
Wm. RITCHIE.

February 16, 1916.

Abstract from the Transactions of the Royal Society of South Africa (Vol. VI.), 1916, on some stages in the Life History of Gnetum. By H. H. W. Pearson, Sc.D., F.R.S., and Mary R. H. Thomson, B.A. (With six plates.)

An account is given of an investigation of the ovule and embryo-sac of *Gnetum africanum* (West Africa), and *G. Gnemon* (Ceylon); the material studied included also *G. Buchholzianum* (West Africa) and *G. scandens* (Poona, Darjeeling, Penang, Singapore), and two species of doubtful identity, one from Singapore and one from Java.

It is shown that in *G. africanum* and *G. Gnemon* the pollen-grain may reach the nucellus in the 3-nucleate condition, in which case the third (prothallial) nucleus does not enter the pollen-tube. The generative cell is organised in the very young pollen-tube. Its nucleus undergoes only one mitosis, resulting in two, sooner or later unequal, sperm-nuclei which usually pass down to the embryo-sac still enclosed in a single unit of protoplasm. The tube-nucleus early shows signs of deterioration and usually disappears before the growth of the pollen-tube is completed.

A simultaneous mitosis in the free nuclear sac (*G. africanum*) has been seen. The account already given of the method of endosperm-formation in the chalazal region in *G. africanum* is confirmed and is extended to *G. Gnemon*. In the micropylar region the endosperm is constituted in precisely the same way (*contra* Lotsy) except in so far as it may be locally interfered with by the activities of pollen-tubes, oospores, or proembryos. Endosperm-formation begins at the chalazal end of the sac and proceeds without interruption to the summit. In some cases (probably usually due to local disturbance) a few of the sac-nuclei neither become fertilised nor participate in the endosperm-fusion. These play no further part in the life history.

The pollen-tube reaches the top of the sac (*G. africanum*) before, or at any time after, the commencement of the formation of chalazal endosperm. In case of the failure of fertilisation, the sac becomes filled with endosperm. These facts together with certain statements made by Karsten tend to show that the distinction drawn by Lotsy between "Karsten's Gneta" and *G. Gnemon* is not justified.

Fertilisation has not been seen. In *G. africanum* the oospore probably gives rise to a mass of proembryos. These become tubular and multinucleate as described by other authors.

A theoretical discussion is concerned with the relationship of the Gnetum sac to (*a*) that of Welwitschia; (*b*) that of the lower gymnosperms; (*c*) that of the angiosperms.

An Ordinary Meeting was held on Wednesday, April 19, 1916, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. L. PÉRINGUEY, took the Chair.

The Minutes of the previous Ordinary Meeting were confirmed.

The following were nominated for membership: Professor J. W. BEWS, M.A., D.Sc.; Mr. H. V. EXNER, B.A.; Dr. O. N. GERICKE, L.R.C.P., L.R.C.S., M.B., Ch.B.; Dr. C. L. HERMAN, M.B., C.M., M.R.C.S.; Professor M. RINDL, D.Ing.

The following communications were made:—

"Note on Pfaffians connected with the Difference-product," by Sir THOMAS MUIR.

In addition to the discovery of the connection referred to in the title, there is established a series of theorems bringing pfaffians into relation with permanents and other integral functions.

"Note on the so-called Vahlen Relations between the Minors of a Matrix," by Sir THOMAS MUIR.

The paper contains a critical examination of the relations in question, and an attempt to put the subject on a sounder basis. There is also incidentally involved a rectification of the statements hitherto accepted regarding the history of the subject.

"On the Development of the Perturbative Function in the Theory of Planetary Motion," by R. T. A. INNES.

The author has published a paper in the Society's Transactions, 1911, upon the Newcomb operators used in the algebraical development of the elliptic perturbative function. The present paper deals with a further extension of the uses of these Newcomb operators. At best the development of the perturbative function is a very cumbersome business, and reference must be made to Newcomb's original paper for a full statement.

"A Contribution to our Knowledge of the National Game of Africa," by P. A. WAGNER.

"Exhibition of some of the Stone 'Boards' on which the Game is Played," by L. PÉRINGUEY.

Among most of the native races of Africa there is played in one form or another, either in rows of holes scooped out of the ground or on wood, stone, or even ivory boards, a peculiar game of skill, that from its wide distribution over the continent has been appropriately styled "the national game of Africa."

The game is described by the author, and is essentially a war game. Two players or sides direct a contest between armies of equal strength, the

object in view being the capture or " killing " of " men " who are represented by small stones, seeds, shells, or fragments of dry cow dung.

" A Survey of the Scorpion Fauna of South Africa," by JOHN HEWITT.

The main features of the Scorpion fauna of S. Africa have been known for some years, though up to the present time no complete lists or descriptions of the fauna as a whole have been available. In this paper an attempt has been made to provide a reliable synopsis of the main distinguishing characters of all the species and varieties known to inhabit S. Africa.

" Note on a Petiole and Portion of the Lamina of *Cotyledon orbiculata* Functioning as a Stem," by S. SCHÖNLAND.

The author describes a case of the formation of adventitious roots on a leaf of Cotyledon orbiculata, which remained attached to its stem for seven months afterwards. The roots grew considerably, the petiole and the lower part of the leaf thickening and resembling the stem in outward appearance. As far as examined, the petiole retained the external structure characteristic of such an organ, and did not turn into a stem as was expected, although it had to perform stem functions for such a long time. In analogous cases in other plants, radical changes have been observed.

An Ordinary Meeting was held on Wednesday, May 17, 1916, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. A. MARIUS WILSON, was in the Chair.

The Minutes of the previous Ordinary Meeting were confirmed.

The following were elected Members: Professor J. W. BEWS, M.A., D.Sc.; Mr. H. V. EXNER, B.A.; Dr. O. N. GERICKE, L.R.C.P., L.R.C.S., M.B., Ch.B.; Dr. C. L. HERMAN, M.B., C.M., M.R.C.S.; Professor M. RINDL, D.Ing.

The name of Dr. PERCY A. WAGNER, D.Ing., B.Sc., Consulting Geologist, Pretoria, was announced as a candidate for Fellowship.

The following communications were made :—

" Oecological Notes on the District of Manubie, Transkei," by W. T. SAXTON.

The area comprises three chief plant formations, namely, woodland, park-like grassland with scattered trees and bushes, and in the more low-lying parts of the latter, sedge vegetation. The soil is essentially uniform throughout the area, being a fine red-brown loam, containing comparatively few large particles or stones. No marked differences in climatic or edaphic factors distinguish the woodland from the grassland, though these are of

strikingly different appearance, and are separated by a sharp boundary line.

WOODLAND.—The great majority of the species, both in the tree layer and in the undergrowth, are dicotyledons. A characteristic tree is *Erythroxylon pictum*, E. Mey.; typical shrubs being *Trichocladus crinitus*, Pers. and *Hibiscus pedunculatus*, Linn. f. In deep moist sheltered glades in the forest occur hygrophilous and shade-loving Pteridophytes and Phanerogams.

GRASSLAND.—The ground is covered with a variety of perennial grasses with which are mingled a profusion of herbaceous perennial phanerogams, while scattered at relatively wide intervals are found some trees and a few hairy shrubs and undershrubs. The principal grass included in this formation is *Digitaria sanguinalis*, Scop. var. *ciliaris*, Prain.

SEDGE.—A point of interest is that the soil of the Cyperaceous formation contained less water than that of the typical grassland. The chief species in this formation are *Fimbristylis complanata*, Link., and *Pycreus umbrosus*, Ness. By small sheltered streams an association of water-loving plants occurs.

The grasses dominating the grassland formation show certain interesting features in their leaf anatomy which are briefly described for *Erianthus Sorghum* and *Digitaria sanguinalis* var. *ciliaris*.

(*a*) "Note on the Radiations emitted by Degenerating Tissues." (*b*) "Note on the Ionisation produced by Degenerating Nerve-muscle Preparations," by J. STEPH. V. D. LINGEN.

The author brings forward some evidence that organic tissues may *post-mortem* give rise to ionisation, which can be detected by the discharge of an electroscope. On the second and third days after death the discharge seems to attain its maximum. There is also some evidence that radiations are given off which can affect photographic plates. The author states that control experiments are in progress.

Consideration of the Communication on the Flow of Holtzhuisbaaken Spring near Cradock was postponed to the following meeting.

An Ordinary Meeting was held on Wednesday, June 21, 1916, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. L. PÉRINGUEY, was in the Chair.

The Minutes of the previous Ordinary Meeting were confirmed.

The following were nominated for membership: E. G. CLIFFORD-JONES, M.I.E.E., M.I.M.E., and J. T. DUNSTAN, M.D., proposed by Dr. A. MARIUS

WILSON, seconded by Dr. L. PÉRINGUEY. D. HOLTZHAUSEN, B.A., proposed by Mr. J. S. v. D. LINGEN, seconded by Professor J. C. BEATTIE. W. v. BONDE, B.A., proposed by Professor W. A. JOLLY, seconded by Professor J. D. F. GILCHRIST. G. T. NICHOLSON, M.I.C.E., proposed by Dr. L. PÉRINGUEY, seconded by Dr. A. MARIUS WILSON.

Demonstrations :—

" Exhibition of some Fossils from the Stormberg Beds of South Africa," by S. H. HAUGHTON.

Specimens of two of the higher Pseudosuchia—*Notochampsa istedana* and *Sphenosuchus acutus*—were exhibited from the Stormberg Beds. Reasons were given for removing the former from the Crocodilia, in which it was originally placed, and for regarding it as a possible link between the Pseudosuchia and the Crocodilia. These forms are links in a chain of evidence which seems to prove that the Stormberg Beds are of Triassic age to the top of the Cave Sandstone, and not Lower Jurassic in the upper parts of the sedimentary series ; many of the reptile remains can be correlated with European Triassic forms, while the flora of the Molteno beds has a Triassic facies.

" Exhibition of a Pelagic Sea-Anemone," by K. H. BARNARD.

The specimen exhibited was taken by the " Pieter Faure." Further specimens are occasionally washed up on the beach in False Bay. A superficial examination seems to show that they are not only generically but also specifically identical with the *Anactinia pelagica* described by Annandale from the Indian Ocean.

The following communications were made :—

" Note on Protective Resemblance in Post-Larval Stages of some South African Fishes," by J. D. F. GILCHRIST.

In *Hemiramphus calabaricus* the post-larval stages of the fish have the size and colour of fragments of weed, which often are found in the waters which these young fish frequent. When alarmed, the fish become rigid and float about in an apparently inanimate condition. When this occurs, it is difficult to distinguish them from the pieces of weed floating around.

In Klipfish (*Clinus spp.*) the young are born alive, and they are of a clear glassy transparency difficult to detect in the water. The contour of the body is probably disguised by a number of minute dark dots.

The colour pattern in other young fish is shown to be more marked and considerably different from that of the adult. Some details of this difference are enumerated in the case of the Leerfish and the Stockfish and a species of Dogfish. It is indicated how this colour pattern of the young fish may be a form of protective resemblance.

" On the Morphology of the Female Flower of Gnetum," by H. H. W. PEARSON.

Much work has been done in recent years on the morphology of the flower of the Gnetales, and very diverse views have been put forward. These are discussed, summarised, and compared in this paper, with special reference to recent investigations by the author and to the conclusions of MM. Lignier and Tison, both as published and as discussed in correspondence with the author. Investigations have tended of late to emphasise the Angiosperm characters of the Gnetales, and MM. Lignier and Tison even reach the conclusion that the innermost envelope of the female flower in Gnetum and Ephedra, and of both flowers in Welwitschia, is a plurilocular ovary containing a single naked ovule. They derive their evidence partly from the anatomical structure of the envelope, partly from its form, terminating as it does in "a long style and a stigma." The anatomical evidence they adduce is discussed in detail, and it is shown that the apparent traces of a vascular system do not necessarily prove the envelope to be an ovary, as well-developed vascular systems are present in the ovular integuments of Cycads and a number of the lower Angiosperms. Regarding the resemblance of the envelope to a carpel with style and stigma, it is pointed out that, external appearances to the contrary, there is no evidence that it is a reduced form of a functional stigma. Its present function is to facilitate the dispersal of pollen by attracting insects, and there is no sufficient reason for supposing that it has ever been concerned in the collection of pollen. The question of the cauline or foliar nature of the Gnetalean ovule arises in this connection; this is discussed in detail, and it is shown that recent investigations tend to confirm the opinion that it is cauline. Finally, the new knowledge furnished by MM. Lignier and Tison for Gnetum is summarised, and their comparisons of the Gnetalean and Angiosperm flowers are reduced to tabular form and correlated with those of other investigators, figures being given to render the comparison and correlation clear.

"Heart Rot of Ptaeroxylon Utile (Sneezewood) caused by Fomes rimosus Berk," by Paul A. v. d. Bijl.

The paper deals with a heart-rot disease in this tree caused by *Fomes rimosus* Berk. The distribution of the fungus and the effect it has on the wood of *Ptaeroxylon utile* are fully recorded.

It appears to have been generally held that this fungus limits itself to *Robinia pseudacacia* or members of the Leguminosae, and it is therefore all the more interesting to know that in the Union of South Africa it has thus far been reported on eleven genera belonging to eight different natural orders.

Ptaeroxylon utile is one of our hardest and most valuable trees, and with endeavours that are being made to get back some of our forests of the past, particular attention should be given to the presence of this fungus in areas demarcated, and every means taken to prevent its spread.

This is all the more important since we now know the fungus attacks a large number of trees belonging to different orders.

The fact that fruiting bodies are not developed after the tree is dead somewhat simplifies the control of the disease along the lines suggested.

An Ordinary Meeting was held on Wednesday, July 19, 1916, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. L. Péringuey, was in the Chair.

The Minutes of the previous Ordinary Meeting were confirmed.

Mr. G. B. Silver Darter, M.B., was proposed for membership by Dr. L. Péringuey, seconded by Dr. A. Marius Wilson.

The following were elected members of the Society: Mr. E. G. Clifford-Jones, M.I.E.E., M.I.M.E.; Dr. J. T. Dunstan, M.D.; Mr. D. Holtzhausen, B.A.; Mr. W. v. Bonde, B.A.; and Mr. G. T. Nicholson, M.I.C.E.

The following communications were made:—

1. "On Pelodrilus Africanus, a New Haplotaxid from South Africa," by E. J. Goddard.

The species here described constitutes the first representative of the family Haplotaxidæ recorded from South Africa. Of the two genera included within this family, one—Haplotaxis—is represented by freshwater species in Europe, North America, and New Zealand, while the remaining genus—Pelodrilus—is represented in New Zealand by a species inhabiting damp earth. The African species is to be included in the latter genus. The specimens were obtained in mud on Sneeuw Kop, near Wellington, Cape Province, at an elevation of 5000 feet above sea level. The length varies from 20 to 40 mm.

2. "Note of Polysaccum Crassipes, a Common Fungus in Eucalyptus Plantations around Pretoria," by Paul A. van der Bijl.

Polysaccum crassipes is so common in Eucalyptus plantations around Pretoria that it appeared interesting to determine in what relation it stood to the Eucalypti.

The investigation was begun at the Botanical Laboratories, Pretoria, and subsequently concluded at the Natal Herbarium, Durban. The morphology of the fungus is briefly dealt with, and followed by suggestions which indicate that the relation between the fungus and host is one of symbiosis. On the Eucalypti roots the fungus forms yellowish masses, and thinner roots may be completely covered or surrounded by the fungus

mass. From these pass delicate rhizomorphic threads which become agglutinated to soil particles or attached to vegetable debris. Inside the host the fungus forms a pseudo-parenchymatous tissue between the cork cells, but does not enter the cells or extend to the wood. The tissues of the plant appear to suffer in no way from the presence of the fungus. The fungus contains a brown colouring matter (in solution) acid to litmus and precipitated from solution as a gelatinous brown precipitate by various strong acids and metallic salts. The precipitate is soluble in ammonia to a dark-brown solution.

An Ordinary Meeting was held on Wednesday, August 16, 1916, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. L. Péringuey, was in the Chair.

The Minutes of the previous Ordinary Meeting were confirmed.

Mr. G. B. Silver Darter, M.B., was elected a Member.

The President made reference to the loss which the Society and Entomological Research have sustained through the death of Mr. R. Trimen, and spoke of his very valuable services to Science.

Demonstration :—

Professor A. Young exhibited specimens of a dark pitch-lustred glass passing into a mixture of glass and imperfectly fused quartz and felspar grains, which in turn graduate into ordinary felspathic sandstone. The specimens were obtained on two farms—Roodekraal and Cyfergat—in the Heilbron district, and occur at the contacts of dolerite intrusions with Karroo sandstone. These are the first recorded cases in South Africa of dolerite intrusions affecting the invaded sandstones to such an extent as to fuse them into a glass. In one case the black glass extended to a distance of several yards from the edge of the dolerite dyke. These contact effects closely resemble those of a contact described in 1904 by Messrs. Harker and Clough as occurring in the islet of Soay in the Western Hebrides of Scotland.

The following communications were made :—

"The Granite of the Schapenberg, Somerset West," by A. R. E. Walker.

The granite of the Schapenberg is essentially a grey, biotite-granito-porphyry intrusive in five grained, argillaceous grits of the Malmesbury series.

It is essentially an apophysis of one or other of the two large granite

masses—the Kuils River granite and the Sir Lowry's Pass granite—which occur, the one to the west and the other to the east of the Schapenberg; most probably of the latter.

Both fine- and medium-grained varieties occur.

At certain points along the contact the granite, owing to absorption of material from the invaded formation, is andalusite-bearing.

The granite, particularly near its margin, has been subjected to pneumatolytic action, which has caused the formation of a series of altered granites ranging from school granite on the one hand to greissen on the other.

The greissen is a quartz-mica-tourmaline rock resembling, in most respects, that of Grainsgill described by Mr. Alfred Harker in the Q.I.C.S.

"On the Radial Lines in Röntgen Interference Patterns," by J. STEPH. V. D. LINGEN.

The author briefly discussed the theory of radial lines, and pointed out that on Friedrich's assumption these lines ought to be present in all interference patterns.

Experiments were then described, which support the view put forward by von Laue and the author, viz., Radial lines are caused by weakening of the lattice of a rigid crystal.

The pattern of $Mg(OH)_2$, where the water molecules were driven off, and re-sublimated Iodine were exhibited, as well as the pattern of sylvine obtained by Friedrich.

The pattern of this Iodine shows the transition stage from a three-dimensional grating to a two-dimensional grating.

MgO from $Mg(OH)_2$ shows the two-dimensional grating only.

"Baurite from Biotite" shows the two-dimensional grating by treating Biotite with acids.

"Some Observations on Ozobranchus Branchiatus," by E. J. GODDARD.

This paper contains an account of the Leech—Ozobranchus branchiatus. Some historical interest attaches to the form, inasmuch as it was probably the first Annulate noted from the Australasian region. The specimens were obtained as parasites on the Green Turtle. The somite is represented in a very primitive condition, and it is of interest to note that the limitation of the genus to Chelonia as parasites is possibly, as in that of Branchellion to Pisces, indicative of an old association, and bearing out the morphological evidence that these forms are archaic and primitive, and ancestral to the Gnathobdellida and Herpobdellida.

The paper deals with the constitution of the somite in the various regions of the body, and the conclusions to be derived from the same.

Annual Meeting.

The Annual Meeting was held on Wednesday, September 27, 1916, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. L. Péringuey, was in the Chair.

Dr. Percy A. Wagner, D.Ing., B.Sc., proposed by Arthur W. Rogers, Alex. L. du Toit, Edw. T. Mellor, Geo. S. Corstorphine, Robert B. Young, and A. L. Hall, was elected a Fellow of the Society.

Some of Dr. Wagner's publications are : " The Diamond-bearing Rocks of S.A.," 1909 ; " Diamond Fields of S.A.," 1914 ; " Geology of the Grootfontein District, S.W.A.," 1910 ; " Notes on the Tin Deposits near Cape Town," 1909 ; " Geology of Portion of the Belingwe District of Southern Rhodesia."

Ordinary Meeting.

An Ordinary Meeting was held on Wednesday, September 27, 1916, in the Board Room of the South African Association, Church Square, Cape Town.

The President was in the Chair.

The Minutes of the previous Ordinary Meeting were confirmed.

Mr. Friedlander was nominated for membership.

The following communications were made :—

" On Some Stages in the Life History of Gnetum," by H. H. W. Pearson and Mary R. H. Thomson.

An account is given of an investigation of the ovule and embryo-sac of Gnetum africanum (West Africa) and G. Gnemon (Ceylon) ; the material studied included also G. Buchholzianum (West Africa) and G. scandens (Poona, Darjeeling, Penang, Singapore) and two species of doubtful identity, one from Singapore and one from Java.

" The Theory of Automatic Regulators," by H. Bohle.

Automatic regulators may be classified as sluggish and fast regulators. The theory of each form of regulator is explained in this paper.

" Variation in the Mylabridae, illustrating a New Theory of Evolution Based on Mendelism," by T. F. Dreyer.

An Ordinary Meeting was held on Wednesday, October 18, 1916, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. L. PÉRINGUEY, was in the Chair.

The Minutes of the previous Ordinary Meeting were confirmed.

Mr. FRIEDLANDER was elected to membership.

The President gave notice of the election of the Council, President, and Officers, and announced the Council's recommendation to the Society as members of Council for 1917 of the following seven members of the existing Council: G. S. CORSTORPHINE, L. CRAWFORD, W. A. JOLLY, C. P. LOUNSBURY, L. PÉRINGUEY, B. ST. J. v. D. RIET, and S. SCHÖNLAND, and the following five fellows: A. J. ANDERSON, W. A. CALDECOTT, S. S. HOUGH, W. F. PURCELL, and A. L. DU TOIT.

The Council further recommended L. PÉRINGUEY as President, L. CRAWFORD as Hon. Treasurer, and W. A. JOLLY as Hon. General Secretary.

Demonstration :—

Mr. A. R. E. WALKER exhibited a collection of minerals obtained in the Beaufort West District from beds of Lower Beaufort age.

It comprised various carbonates—calcite and most probably aragonite and baryto-calcite—barytes and the radio-active minerals, uranocircite and torbernite. The minerals chiefly occur encrusting and replacing fossil wood. One specimen showed uranocircite and tobernite occurring disseminated throughout a fine-grained sandstone.

Photographs, showing the effects produced by the radio-active minerals on a photographic plate, were also shown.

The following communications were made :—

"African Myxomycetes," by Miss A. V. DUTHIE.

In this preliminary paper an attempt has been made to compile a list of the species of Myxomycetes previously recorded from Africa in various journals and monographs, and also to record forms which have been accessible to or collected by the author. The collections of the Mycological Herbarium, Pretoria, and a list of the forms in Rev. C. Kalchbrenner's collection, have been placed at the author's disposal.

"On Hybrid Forms in the Genus Satyrium, with Descriptions of Two New Forms," by Miss A. V. DUTHIE.

The paper contains a description of two hybrids from Tulbagh, one Satyrium erectum Xcoriifolium, the other Satyrium erectum Xbicorne. A detailed description, with illustrations, is given of the vegetative and floral structures in each form. The morphological evidence is supported by

observations on the parent forms (in conjunction with the natural association of the same), such as frequency of pollination, scent of flowers, presence of free honey, life of the flowers, and insect pollination.

Mention is made of other known South African hybrids in the genus Satyrium.

"Ionization of Gases and the Absorption of Röntgen Rays," by LEWIS SIMONS.

The independence of X-ray effects of molecular aggregations and the dependence only on the atoms present, together with the fact that it has been shown that the absorption of a given wave-length in a solid varies as the fourth power of the atomic number of the solid, whilst for a gas the primary β ionization also varies as the fourth power of the atomic number of the atom ionized, leads to the conclusion that absorption in solids (apart from scattering) is due throughout to the production of β particles.

The fall in the constant of proportion between the absorption per atom and N^4 when a K line ceases to be excited, is shown to be :—

$$\frac{LN_K + LN_L + LN_M + \cdot \cdot \cdot \cdot}{LN_L + LN_M + \cdot \cdot \cdot \cdot}$$

and when an L line ceases to be excited :—

$$\frac{LN_L + LN_M + \cdot \cdot \cdot \cdot}{LN_M + \cdot \cdot \cdot \cdot}.$$

"Note on the Occurrence of Daphnin in the Arthrosolen," by M. RINDL.

The author has determined the presence of daphnetin and glucose in *Lasiosiphon polycephalus*, a perennial shrub which flowers in August and September, known to the South African farmers as Januariebosje, and assumes that the glucoside daphnin has been present and hydrolysed in the process of extraction.

ANNIVERSARY MEETING.

The Anniversary Meeting of the Society was held on Wednesday, March 21, 1917, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. L. PÉRINGUEY, was in the Chair.

The Report of the Hon. General Secretary was submitted and adopted.

The Report of the Hon. Treasurer was submitted and adopted.

The following were elected Members of the Council for the year 1917 :—

Dr. A. JASPER ANDERSON.	Dr. W. A. JOLLY.
Dr. W. A. CALDECOTT.	Mr. C. P. LOUNSBURY.
Dr. G. S. CORSTORPHINE.	Dr. L. PÉRINGUEY.
Dr. L. CRAWFORD.	Dr. W. F. PURCELL.
Dr. A. L. DU TOIT.	Dr. S. SCHÖNLAND.
Mr. S. S. HOUGH.	Dr. B. DE ST. J. VAN DER RIET.

Dr. L. PÉRINGUEY was elected President.

Dr. L. CRAWFORD, Hon. Treasurer.

Dr. W. A. JOLLY, Hon. General Secretary.

The President announced his nomination, as Vice-Presidents, of Dr. A. JASPER ANDERSON and Dr. G. S. CORSTORPHINE.

ORDINARY MEETING.

An Ordinary Meeting was held on March 21, after the Anniversary Meeting.

The President was in the Chair.

The Minutes of the Ordinary Meeting held on October 18, 1916, were confirmed.

Dr. E. T. STEGMANN, B.A., D.Sc., and Mr. S. H. SCAIFE were nominated for election as Members.

The following communications were made :—

"Note on Palmström's Generalization of Lamé's Equation," by Sir THOMAS MUIR.

"Mestoma Antarcticum from Bloemfontein" (*sp. nov.*), by T. F. DREYER.

This paper contains the description of a very slender worm, tapering towards both ends, and when fully extended about 7 mm. in length and about 1 mm. broad, found in a small pond on clay soil near Bloemfontein. The specimen shows an almost negligible amount of variation from *M. mutabile* from Tierra del Fuego ; whether this similarity is due to parallel evolution, or to a former land connection, or to dispersal by birds, must remain an open question.

"Colour and Chemical Constitution : A Study of the Phthaleins and Related Compounds," by JAMES MOIR.

REPORT OF THE HON. GENERAL SECRETARY FOR THE YEAR ENDING DECEMBER 31, 1916.

Seven Ordinary Meetings, the Annual and the Anniversary Meetings, were held during the year, and the following papers were read :—

"Note on Pfaffians connected with the Difference-product," by Sir THOMAS MUIR.

"Note on the so-called Vahlen Relations between the Minors of a Matrix," by Sir THOMAS MUIR.

"On the Development of the Perturbative Function in the Theory of Planetary Motion," by R. T. A. INNES.

"A Contribution to our Knowledge of the National Game of Skill of Africa," by P. A. WAGNER.

"A Survey of the Scorpion Fauna of South Africa," by JOHN HEWITT.

"Note on a Petiole and Portion of the Lamina of *Cotyledon orbiculata* Functioning as a Stem," by S. SCHÖNLAND.

"Oecological Notes on the District of Manubie, Transkei," by W. T. SAXTON.

"Note on the Radiations emitted by Degenerating Tissues and Note on the Ionisation produced by Degenerating Nerve-muscle Preparations," by J. STEPH. V. D. LINGEN.

"Note on Protective-Resemblance in Post-larval Stages of some South African Fishes," by J. D. F. GILCHRIST.

"On the Morphology of the Female Flower of Gnetum," by H. H. W. PEARSON.

"Heart Rot of Ptaeroxylon Utile (Sneezewood) caused by Fomes rimosus Berk," by PAUL A. V. D. BIJL.

"On Pelodrilus Africanus, a New Haplotaxid from South Africa," by E. J. GODDARD.

"Note on Polysaccum Crassipes, a Common Fungus in Eucalyptus Plantations around Pretoria," by PAUL A. V. D. BIJL.

"The Granite of the Schapenberg, Somerset West," by A. R. E. WALKER.

"On the Radial Lines in Röntgen Interference Patterns," by J. STEPH. V. D. LINGEN.

"Some Observations on Ozobranchus Branchiatus," by E. J. GODDARD.

"On Some Stages in the Life History of Gnetum," by H. H. W. PEARSON and MARY R. H. THOMSON.

"The Theory of Automatic Regulators," by H. BOHLE.

"Variation in the Mylabridae illustrating a New Theory of Evolution based on Mendelism," by T. F. DREYER.

"African Myxomycetes," by Miss A. V. Duthie.

"On Hybrid Forms in the Genus Satyrium with Descriptions of Two New Forms," by Miss A. V. Duthie.

"Ionization of Gases and the Absorption of Röntgen Rays," by Lewis Simons.

"Note on the Occurrence of Daphnin in the Arthrosolen," by M. Rindl.

The Society has awarded, on the recommendation of the General Committee for Grants in Aid of Research, the following grant: £50 to Mr. J. S. v. d. Lingen for continuation of research work on Radiology generally.

During the past year further progress has been made with the cataloguing of the Society's library. The publications of the undermentioned Societies have been examined and catalogued, and communications are proceeding with the Societies regarding filling up of blanks.

Royal Society of New South Wales.
Linnean Society of New South Wales.
Australian Museum, Sydney.
Royal Society of South Australia.
Royal Geographical Society of Australasia.
Adelaide Observatory.
University of Sydney.
Melbourne Observatory.
Royal Society of Victoria.
Victoria Public Library, Museum, and National Gallery.
National Museum, Melbourne.
Tasmania, Department of Mines.
Royal Zoological Society of New South Wales.
New Zealand Institute.
Royal Society of Tasmania.
Queensland Museum.
Royal Society of, Queensland.
Australasian Association for the Advancement of Science.

Vol. V., parts 3, 4, and 5 of the Society's Transactions have been issued during the year. Other parts which would have been issued in 1916 have been unavoidably delayed owing to the unusual conditions prevailing at present.

The number of Honorary Fellows is 3; Fellows, 50; Members, 168. Dr. Percy A. Wagner, D.Ing., B.Sc., has been elected a Fellow in 1916.

The Society regrets to have to record the death, since the 1915 Anniversary Meeting, of Professor H. H. W. Pearson, Fellow, and H. A. Fry and Dr. C. M'Gowan Kitching, Members.

TREASURER'S ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1916.

Receipts.

	£ s. d.	£ s. d.
To Balance in Bank as per Pass Book		116 8 3
,, Subscriptions received in 1916:		
for 1914, 2 Fellows at £2, 2 Country Members at £1	6 0 0	
for 1915, 4 Fellows at £2, 3 Town Members at £2, 11 Country Members at £1, balance 1 Country Member 19s., balance 1 Country Member 16s.	26 15 0	
for 1916, 41 Fellows at £2, balance 1 Fellow £1, 16s., 42 Town Members at £2, balance 1 Town Member £1, 18s., 81 Country Members at £1, balance 1 Country Member 19s., balance 1 Country Member 18s., £1 extra Subscription from Country Member elected Fellow	253 11 0	
for 1917, 1 Country Member at £1, part Subscriptions 3s.	1 3 0	
		287 9 0
,, Entrance Fees received, 10 new Members		10 0 0
,, Sale of Publications to Government		100 0 0
,, Sales of Publications otherwise		38 12 6
,, Sales of extra Reprints of Papers		34 16 0
,, Government Grant, 1915–16		50 0 0
,, Government Grant, 1916–17		50 0 0
,, Interest on Fixed Deposit in Standard Bank, 1915–16		32 0 0
,, Cash drawn from Post Office Savings Bank		300 0 0
		£1019 5 9

Expenditure.

	£ s. d.
By Publications	486 11 0
,, Landing Charges, etc.	11 18 3
,, Research Grants and Expenses	78 18 9
,, Cost of stamps on retaining £800 for one year on Fixed Deposit at Standard Bank	0 4 0
,, Payments in connection with Grant to Professor Pearson for Botanical Exploration in Namaqualand, closing account	44 6 3
,, Compilation for International Scientific Catalogue of Papers	25 0 0
,, Clerical Assistance and Work in Library	55 0 0
,, Local Printing and Stationery	33 6 10
,, Postages and Petties	48 16 3
,, Bank Charges for Commissions, Ledger Fees, Cheque Book, less Commissions paid by Members	1 16 2
,, Hire Room for Meetings and Caretaker, 1916	5 15 6
,, Cash, Entrance Fees received 1916, put into Post Office Savings Bank	10 0 0
,, Balance in Bank as per Pass Book	217 12 9
	£1019 5 9

ASSETS AND LIABILITIES AS AT DECEMBER 31, 1916.

Assets.	£	s.	d.
Money at Standard Bank on Fixed Deposit at 4 per cent.	800	0	0
Money in Post Office Savings Bank, Life Subscriptions and Entrance Fees	144	0	0
Money in Post Office Savings Bank, at call, with Interest to March 31, 1916..	131	8	6
Balance in Standard Bank, as per Pass Book	217	12	9
Petty Cash in hands of Hon. Secretary	1	15	3
Arrears of Subscriptions, as in Statement for 1915, due at beginning of 1916, £55, 15s., less £32, 15s. paid in year and £10 struck off as irrecoverable	13	0	0
Arrears of 1916 Subscriptions	63	0	0
Money due for Sale of Publications	2	16	10
Money due for Sale of Extra Reprints of Papers	4	5	0
	£1377	18	4

Liabilities.	£	s.	d.
Subscriptions, whole or in part, received for 1917	1	3	0
Balance Research Grant voted in 1914 to Miss M. Wilman..	25	0	0
Earmarked for Expense of Publishing, as a part of the Transactions, a reproduction of a Bushman Painting (Council Minutes, May 12, 1915) a sum not exceeding	350	0	0
Balance from 1912 Conversazione carried forward towards the expenses of future Conversazione in Cape Town	7	4	0
	£383	7	0

We have audited the accounts and checked the vouchers of the Royal Society of South Africa for the year 1916, and find the same, to the best of our belief, correct.

S. S. HOUGH.
ALEXANDER BROWN.

February 12, 1917.

NOTE.—Owing to the abnormal delay in sending out the Transactions of the Society, an account falls to be paid in 1917 for the printing of Vol. V., Pt. 6 and Vol. VI., Pt. 1, ordered in 1916. This account is roughly estimated to be £550.

An Ordinary Meeting was held on Wednesday, April 18, 1917, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. L. Péringuey, was in the Chair.

The Minutes of the previous Meeting were confirmed.

Professor R. B. Young was admitted a Fellow of the Society.

Dr. E. T. Stegmann and Mr. S. H. Scaife were elected Members.

Exhibits :—

The President exhibited polychrome and monochrome paintings, executed on river-water and other flat stones found in exploring caverns occupied by the Strand Looper Sans along the littoral of the Cape. These paintings are of a type superior in some cases to the well-known parietal paintings of the Bushmen of the Interior. They were found lying, and in some cases with the painting downwards, on or slightly above the flexed skeleton. That the paintings were executed for inhumation purposes and were not detached from painted scenes on parietal surfaces is proved by the painting being continued on the side of the fractured slab. The technique and pigments are, however, those of the inland Bush, and this alone would go far to prove the identity of the Strand Looper with the Bushman as one race. The Bush painted and graved ; the Hottentot neither paints nor graves. Singularly enough the name Hottentot should apply to that race which is now dubbed Bushman. One of the scenes corroborates details of the Hottentot (Strand Looper) deportment, given by Captain Beaulieu, who touched at Table Bay in 1621.

Mr. S. H. Haughton exhibited an almost complete skeleton of a specimen of fossil reptile from the middle Beaufort Beds.

The specimen exhibited was obtained by Dr. A. L. du Toit in Natal, and was associated with portions of skulls of undoubted species of *Lystrosaurus*. Apart from the fact that the skull and lower jaw are associated with the larger part of the skeleton, the specimen is of interest in that it seems to form a link between some Dicynodons of the *Cistecephalus* zone and *Lystrosaurus* proper. The snout is bent down as in the latter genus ; but it is not so greatly elongate. The relations of the bones of the top of the skull are typically Dicynodont. The upper border of the ilium is notched as in *Lystrosaurus*, but there are only two notches instead of three. In view of its intermediate character it has been thought advisable to create for it a new genus, *Prolystrosaurus*, which is also considered to include the form described as *Dicynodon strigops*.

Mr. K. H. Barnard exhibited shells collected in Namaqualand by Dr. Rogers.

Examples of most of the known species and varieties of the *Dorcasiinae*

were shown together with some specimens of the allied subfamilies from other parts of the world. Remarks were made on the supposed phylogeny of the family according to the recent anatomical researches of Watson, and on the variation in the Helicoid form according to habitat.

Dr. A. L. du Toit exhibited some hybrid graphite-bearing rocks from Natal.

These are found at the Ingeli and near Ladysmith, and have been produced by the intrusion of dolerite into carbonaceous shale. The latter has been disrupted, and all stages are seen up to a breccia, in which small fragments of shale are embedded in an igneous matrix, the sedimentary rock having been completely recrystallised with the development of graphite and silicates, while the dolerite by reaction and incorporation of silica from the inclusions has been acidified and is now pale in colour.

The following communications were made :—

"Note on the Expansion of the Product of Two Oblong Arrays," by Sir Thomas Muir.

The form taken by Binet and Cauchy's well-known expansion of the year 1812 is that of a sum of products of pairs of determinants : the form of the expansion now given is that of an aggregate of single determinants. The relation between the two is explained and a historical remark added.

"Notes on Radiation of Crystals," by J. Steph. v. d. Lingen.

(*a*) Radiation patterns of the transformation of Magnesium Hydroxide to Magnesium Oxide. The patterns show that the reflecting planes of the crystal are disturbed when water is driven off. The patterns show that the "spots" become drawn out into radial lines and that these radial lines reflect the intensity of the X-ray Spectrum. These observations show that Friedrich's two-dimensional grating may only be attributed to crystals under definite physical conditions.

(*b*) Diamond tests by Radiation patterns.

The following stones were examined :—

"Macle," "spotted" stone, "spotted rejection" stone, and an "inferior brown block" with a spot in it. The patterns show that a "spot" in a stone causes a discontinuity in the intensity of individual spots of the patterns, and that a fracture of the lattice causes a discontinuity of the spots so that they now represent irregular markings on the plate. An ideal diamond's pattern shows a uniform intensity in all the spots.

(*c*) Bultfontein Apophyllite, (i) Ideal and (ii) showing a cleavage crack along a cleavage plane.

The flaw causes the spots of the "flawed" crystal to present a nebular appearance, whereas the Ideal stone shows a uniform distribution of intensity in the elliptic spots. This represents a case of discontinuity in the lattice normal to the incident rays.

(*d*) *Serpentine*, Malachite and Pseudomorph Quartz.

Serpentine shows a regular " radial line " pattern symmetrical to a line parallel to the threads of the crystal. This indicates that Serpentine is not triclinic unless every specimen examined was a " twin."

Malachite.—Shows three " lines " parallel to the threads and some minor radial lines normal to the former deviating slightly from the normal.

Crocidolite.—Along exposure shows that it is microcrystalline and that the elementary units have a tendency to favour a direction parallel to the threads.

(*e*) A square-plate of Iodine showed, after an exposure of about an hour, diffraction, a phenomenon similar to that described by Professor Laub of Buenos Ayres.

In this case the plate shows diagonal lines of zero intensity.

" A Summary of the Distribution of the Genera of South African Flowering Plants (with special reference to the Flora of the Uitenhage and Port Elizabeth Divisions)," by S. Schönland.

This is to a large extent based on published data checked and enlarged, however, by the author's personal knowledge. It was compiled in connection with a study of the Flora of Uitenhage and Port Elizabeth, but it is hoped that it may be welcome to other Botanists who desire to have readily available a summary showing the general trend of distribution of South African genera.

" Note upon the Endocranial Cast obtained from the Ancient Calvaria found at Boskop, Transvaal," by G. Elliot Smith.

The author describes the cast representing the form of the cranial cavity of the skull-cap from Boskop described by Mr. S. H. Haughton, and states that whatever the date of the Boskop remains may be, the evidence now in our possession suggests that this early inhabitant of the Transvaal represents the type of the immediate ancestors of the men of the Upper Palaeolithic Age, possibly somewhat modified in the course of his Southern migration. It probably represents the earliest (not necessarily in actual age) known phase of *Homo sapiens* in the course of his transformation from a condition analogous to that of Neanderthal man to that of Cro-Magnon.

An Ordinary Meeting was held on Wednesday, June 20, 1917, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. L. Péringuey, was in the Chair.

The Minutes of the previous Meeting were confirmed.

Mr. J. Boyd, F.I.C., A.R.T.C. (Glasgow), was elected a Member.

Notice of Motion was given by Mr. C. W. Mally with reference to the preservation of anatomical material.

Exhibitions :—

Miss J. E. Smith, M.Sc., gave an exhibition of some higher fungi and lichens found in South Africa. The exhibits included some interesting forms from the National Botanic Gardens, Kirstenbosch, among them *Tremella frondosa*, *Agaricus deliciosum* (an edible fungus, allied to the Mushroom, very common at Kirstenbosch), and a Peziza, found inside the stem of a tree fern. Attention was drawn to the diverse adaptations for spore protection and dispersal.

Mr. C. W. Mally gave an exhibit of the beetle *Formicomus coeruleus*, which attacks and devours the living pernicious scale. This beetle is not merely a scavenger, but from Mr. Mally's observations it is clear that scale insects are killed by it, and it may be a valuable auxiliary in the destruction of the scale.

The following communications were made :—

"Note on a Case of Hermaphroditism," by H. V. Exner.

The author describes as a case of Hermaphroditism the body of a person of unsound mind, who had the outward appearance of a Kafir girl. The nature of the case was only recognised after a histological study of the genital organs.

"Note on the Genus Terfezia : a Truffle from the Kalahari," by I. B. Pole-Evans.

Attention is drawn to the fact that *Choeromyces*, a truffle hitherto unknown to Africa, has recently been reported from South Africa. The author points out that the best known South African truffles belong to the genus *Terfezia*.

The distinction between *Choeromyces* and *Terfezia* is indicated, and a description is given of a truffle (*T. Claveryi* Chat.) recently sent to the author from the Griqualand West district in the Kalahari.

An Ordinary Meeting was held on Wednesday, August 15, 1917, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. L. Crawford was in the Chair.

The Minutes of the previous Meeting were confirmed.

The following communications were made :—

"Note on the Resolvability of the Minors of a Compound Determinant," by Sir Thomas Muir.

"Colour and Chemical Constitution. Part II. : The Spectra of the Mixed Phthaleins and of the Sulphone-phthaleins," by James Moir.

Mixed phthaleins, containing two different phenol residues, one of which is C_6H_4OH, are made with extraordinary ease by boiling paraoxybenzophenone-o-carboxylic acid with any phenol or amine, whether free or substituted. The spectra of eighteen new phthaleins of this class are described, and the laws governing the colour elucidated. The method is an excellent analytical one for identifying phenols and amines and their ethers and derivatives. The spectrum of phenolthymolphthalein is not exactly half-way between those of phenolphthalein and thymolphthalein. The spectra of five sulphonephthaleins made from "saccharin" are also described, also six more new derivatives of ordinary phenolphthalein (see Part I.).

A new general formula for the coloured substances is put forward.

"Kimberley Diamonds: especially Cleavage Diamonds," by J. R. Sutton.

This paper is a general and statistical account of the diamonds produced in the mines under the control of the De Beers Company at Kimberley. It describes the outstanding differences in size, colour, and type, between the yields of the different mines, speaks of coloured diamonds, bort, and especially cleavage diamonds; and advances a view that many diamonds have been naturally broken by the unequal expansion of themselves and mineral inclusions. It appears that brown diamonds have shown a particular disposition to come up broken from the deeper levels of the Wesselton mine (though the ratio of colourless cleavage to colourless stones also increases with depth of mining), but the author doubts the common assertion that brown or smoky diamonds are markedly liable to spontaneous fracture.

"On the Phanerogamic Flora of the Divisions of Uitenhage and Port Elizabeth," by S. Schönland.

This paper is meant to be a companion to the papers published by the late Dr. Bolus and Major Wolley Dod on the Flora of the Cape Peninsula, and by the late Dr. J. Medley Wood on the Flora of Natal. There are 2290 species recorded, of which 98 are considered by the author not to be native. They are distributed over 128 natural orders and 712 genera. There are, however, still large tracts of this area unexplored. Most of the localities quoted are contained in about 600 square miles, while the total area is about 2500 square miles; much of the remaining tract is, however, covered by fairly uniform karroid succulent vegetation.

"A Lunar Period in the Rates of Evaporation and Rainfall," by J. R. Sutton.

This paper calls attention to the possibility of a lunar influence governing the evaporation from a water surface, and a lunar period in the incidence of rainfall. Tables are given showing that as the result of hourly observations of evaporation and rainfall during the 120 lunar months from August 1899 to April 1909, rainfall has its maximum frequency about the time of

moonrise, and its minimum just after moonset; also that the rate of evaporation has a maximum and minimum, respectively, shortly after the moon passes the meridian above and below the horizon.

Annual Meeting.

The Annual Meeting was held on Wednesday, September 26, 1917, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. L. Péringuey, was in the Chair.

Dr. Charles Edward Moss, M.A., D.Sc., B.Sc., F.L.S., F.R.G.S., proposed by Joseph Burtt-Davy, R. T. A. Innes, R. B. Young, and A. Ogg; and Mr. Charles William Mally, M.Sc., F.E.S., F.L.S., proposed by Joseph Burtt-Davy, Chas. P. Lounsbury, W. A. Caldecott, R. T. A. Innes, R. B. Young, and Robert A. Lehfeldt, were elected Fellows.

Ordinary Meeting.

An Ordinary Meeting was held on Wednesday, September 26, 1917, in the Board Room of the South African Association, Church Square, Cape Town.

The President was in the Chair.

The Minutes of the previous Ordinary Meeting were confirmed.

Miss E. L. Stephens exhibited specimens of eleven parasitic plants belonging to the genera Cassytha, Hydnora, Viscum, Striga, Loranthus, Hyobanche, Harveya, and Sarcophyte, and made some brief remarks on their structure and biology.

The following communications were made:—

"Note on the Abnormal Development of the Genital Organs of Jasus Lalandii," by W. von Bonde.

The author records a peculiar abnormality in a male Cape Crawfish.

Three distinct genital apertures are developed, two normally, and a third abnormally, the latter occurring on the fourth walking leg of the right side.

Internally the *vas deferens* of the right bifurcates, sending a branch to the normal opening and a second to the abnormal aperture.

"On the Colour-Octahedron as a Complexity: being Suggestions towards a Mathematics of Colour," by G. H. Malan.

Developing certain ideas of Meinong, who contends that the possibility of representing certain well-known facts in connection with Colour-Psy-

chology by a diagram in the form of an octahedron rests on the presence of certain *a priori* relations incidental to the very nature of colour itself, the writer is led to examine Meinong's contention critically in the light of modern Mathematical Logic (as expounded by B. Russel). The result of this examination is (1) to show that Meinong's theory, though true in its intention, is seriously at fault in its practical conception of an *a priori* science of colour, because of the ignorance of its author of the principles of mathematics as revealed by recent researches of mathematicians; and (2) to necessitate a more exact discrimination between the standpoints of Empirical Psychology and Mathematical Science. In order to sustain his negative criticism of Meinong's "Geometry of Colours," the writer then endeavours to prove that the formal relations obtaining between colours are the very same as those with which mathematics is ordinarily conversant, and to formulate a few provisional though fairly definite laws of the kind which colour-mathematics has to determine.

"A List of South African Fungi," by Miss A. M. BOTTOMLEY.

This paper is a systematic compilation, with indexes of all the South African Fungi in the Government Mycological Herbarium. It records some 276 genera and 800 named species, some of the more important or more interesting of which are illustrated by photographs of actual specimens.

Considerable space is occupied by the Rusts, the Perisporiales, and the Pore Fungi, three groups which are receiving particular attention in the Mycological Department.

An Ordinary Meeting was held on Wednesday, October 17, 1917, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. A. JASPER ANDERSON, Vice-President, was in the Chair.

The Minutes of the previous Meeting were confirmed.

Mr. C. D. LESLIE and Mr. BERNARD PRICE were elected Members.

Mr. L. P. BOSMAN, B.A., and Professor R. W. WILCOCKS were nominated for membership.

The Chairman gave notice of the election of the Council, President, and Officers, and announced the Council's recommendation to the Society as members of Council for 1918 of the following seven members of the existing Council: A. JASPER ANDERSON, W. A. CALDECOTT, G. S. CORSTORPHINE, L. CRAWFORD, S. S. HOUGH, W. A. JOLLY, and L. PÉRINGUEY; and the following 5 Fellows: J. C. BEATTIE, J. D. F. GILCHRIST, J. MOIR, I. B. POLE-EVANS, and Sir A. THEILER.

The Council further recommend J. D. F. GILCHRIST as President, L. CRAWFORD as Hon. Treasurer, and W. A. JOLLY as Hon. General Secretary.

The following communications were made :—

"Spectrum Phenomena in the Chromium Compounds : being Part IV. of the Spectrum of the Ruby and Emerald," by JAMES MOIR.

It has been found that although aqueous solutions of the chromium salts do not show any narrow characteristic bands in the spectrum, yet when anhydrous (or nearly anhydrous) solutions are used, the spectrum is crossed by narrow bands in the red similar to what are seen in the ruby or emerald spectrum.

The solutions of chromium oxide in conc. sulphuric and in fused metaphosphoric acid have been investigated and the bands measured ; they are very similar to those seen in the emerald, but not absolutely identical ; whilst the bands of the ruby, although similar in arrangement, are displaced into a region of lower frequency. Both gem colours are due to chromium, but the vibrations are differently loaded (silica and beryllia against alumina).

"Colour and Chemical Constitution. Part III. : Derivatives of the Unknown Ortho-para-phenolphthalein," by JAMES MOIR.

Phthaleins in which one of the hydroxyl-groups is *ortho-* and the other *para-* to the central carbon have been prepared from para-substituted phenols with oxybenzoylbenzoic acid. They are like the common phthaleins, but their absorption-bands are broad, although in much the same position. An attempt to make *o-p*-phenolphthalein itself gave a product very closely resembling common phenolphthalein, and a similar substance was obtained by dehydrating oxybenzoylbenzoic acid alone with sulphuric acid. They are, nevertheless, probably not identical with common phenolphthalein. "Phenolphthaleinoxime" is not an oxime, but is the *p*-oxyanil of oxybenzophenonecarboxylic acid. Common phenolphthalein in normal alkali is colourless when cold, but becomes pink on warming.

ANNIVERSARY MEETING.

The Anniversary Meeting of the Society was held on Wednesday, March 20, 1918, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. L. PÉRINGUEY, was in the Chair.

The Report of the Hon. General Secretary was submitted and adopted.
The Report of the Hon. Treasurer was submitted and adopted.

The following were elected Members of the Council for the year 1918:—

Dr. A. JASPER ANDERSON.	Mr. S. S. HOUGH.
Dr. J. C. BEATTIE.	Dr. W. A. JOLLY.
Dr. W. A. CALDECOTT.	Dr. J. MOIR.
Dr. G. S. CORSTORPHINE.	Dr. L. PÉRINGUEY.
Dr. L. CRAWFORD.	Mr. I. B. POLE-EVANS.
Dr. J. D. F. GILCHRIST.	Sir A. THEILER.

Dr. J. D. F. GILCHRIST was elected President.

Dr. L. CRAWFORD, Hon. Treasurer.

Dr. W. A. JOLLY, Hon. General Secretary.

The President referred to the loss sustained by the Society through the death of the late Professor P. D. HAHN, and spoke of his great services to the Society and to Science in South Africa.

REPORT OF THE HON. GENERAL SECRETARY FOR THE YEAR ENDING DECEMBER 31, 1917.

Six Ordinary Meetings, the Annual Meeting and the Anniversary Meeting, were held during the year, and the following papers were read:—

"Note on Palmström's Generalization of Lamé's Equation," by Sir THOMAS MUIR.

"Mestoma Antarcticum from Bloemfontein" (*sp. nov.*), by T. F. DREYER.

"Colour and Chemical Constitution: a Study of the Phthaleins and Related Compounds," by JAMES MOIR.

"Note on the Expansion of the Product of Two Oblong Arrays," by Sir THOMAS MUIR.

"Notes on Radiation of Crystals," by J. STEPH. V. D. LINGEN.

"A Summary of the Distribution of the Genera of South African Flowering Plants (with special reference to the Flora of the Uitenhage and Port Elizabeth Divisions)," by S. SCHÖNLAND.

"Note upon the Endocranial Cast obtained from the Ancient Calvaria found at Boskop, Transvaal," by G. ELLIOT SMITH.

"Note on a Case of Hermaphroditism," by H. V. EXNER.

"Note on the Genus Terfezia: a Truffle from the Kalahari," by I. B. POLE-EVANS.

"Note on the Resolvability of the Minors of a Compound Determinant," by Sir THOMAS MUIR.

"Colour and Chemical Constitution. Part II.: The Spectra of the Mixed Phthaleins and of the Sulphonephthaleins," by JAMES MOIR.

"Kimberley Diamonds: especially Cleavage Diamonds," by J. R. Sutton.

"On the Phanerogamic Flora of the Divisions of Uitenhage and Port Elizabeth," by S. Schönland.

"A Lunar Period in the Rates of Evaporation and Rainfall," by J. R. Sutton.

"Note on the Abnormal Development of the Genital Organs of Jasus Lalandii," by W. von Bonde.

"On the Colour-Octahedron as a Complexity: being Suggestions towards a Mathematics of Colour," by G. H. Malan.

"A List of South African Fungi," by Miss A. M. Bottomley.

"Spectrum Phenomena in the Chromium Compounds: being Part IV. of the Spectrum of the Ruby and Emerald," by James Moir.

"Colour and Chemical Constitution. Part III.: Derivatives of the Unknown Ortho-para-phenolphthalein," by James Moir.

The Society has awarded, on the recommendation of the General Committee for Grants in Aid of Research, the following grants: £100 to Professor J. T. Morrison, for investigation of earth-tides; £40 to Mr. J. S. v. d. Lingen, for continuation of researches in radiology; £35 to Professor M. Rindl, for chemical investigation of some toxic and medicinal South African plants; £35 to Professor S. J. Shand, for a study of the alkaline igneous rocks of the Transvaal; £32, 10s. to Mr. K. H. Barnard, for the collection of terrestrial and fresh-water crustacea in the Union; £32, 10s. to Professor J. W. Bews, for research on the plant succession in the grass veld of South Africa; £25 to Professor Geo. Potts, for a botanical survey in the Orange Free State.

A catalogue of the publications available in the Society's library is now published in a work prepared and printed for the Trustees of the Public Library, Cape Town, entitled "Cape Peninsula List of Serials." This is a catalogue of the publications available in the principal libraries of the Peninsula, and a copy is available for the use of anyone using the library.

A number of volumes of the Proceedings and Transactions of the Zoological Society of London were kindly presented to the Society by Canon M. M. Wood.

The sum of £10 having been voted for binding, a commencement has been made with the Proceedings of the Royal Society of London (Sections A and B), forty volumes of which are now in the hands of the binder. It is hoped that an annual vote may be made to carry on the binding of the contents of the library.

During the year it became necessary to remove the surplus stock of Transactions of the Society (S.A. Phil. Soc., and Roy. Soc. of S.A.). The stock was therefore removed, packed in suitably sized packages, labelled,

and placed on the top of the shelving occupied by the Society's library in the S.A. College Library, this being the only available place.

Owing to the want of sufficient shelving, certain publications in the library have had to be merely stacked together, so as to save space, and this renders them not only untidy in appearance but less convenient for reference, and the time is at hand when, unless additional shelving is provided, some of the contents of the library will have to be packed up and stored away to make room for the annual increase.

The matter of additional shelving has been brought forward annually since the Report for 1913, and the position now is that before the extra shelving can be erected a storeroom to accommodate over two hundred packages of stock, in addition to stationery, etc., will have to be provided, as the extra shelving can only be erected on the top of the present shelving, there being no lateral space available.

Vol. V., Part 6, and Vol. VI., Parts 1, 3, and 4, of the Society's Transactions have been issued during the year. (Vol. VI., Part 2, will be issued early in 1918.) The exceptional delay in the publication of the papers contained in these parts was quite unavoidable, owing to accidents at the printing works on two occasions and to the difficulty of obtaining material.

The number of Honorary Fellows is 3, Fellows 50, Members 165.

The Society regrets to have to record the death since the 1917 Anniversary Meeting of Professor P. D. Hahn, Fellow, Dr. H. Becker, Mr. D. J. Haarhoff, Life Member, Mr. A. G. Howitt, M.C., Member on Military Service, Mr. S. Mendelssohn, Member, and Mr. W. Wardlaw Thompson, Member. Mr. E. Jacot, Member on Military Service, has been reported missing.

The Society desires to record that Lieut. L. H. Walsh, Member on Military Service, has been awarded the Military Cross in addition to the D.C.M. gained in 1916.

A resolution was passed by the Society that the subscriptions of a member on active or national service be remitted for the time of his absence from the Union of South Africa, and that the parts of Transactions published during his absence be sent to him without charge when he returns to civilian life, provided that he intimates his intention to resume membership of the Society.

TREASURER'S ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1917.

Revenue.

	£ s. d.	£ s. d.
To Subscriptions received in 1917 :		
for 1915, 1 Fellow at £2	2 0 0	
for 1916, 4 Fellows at £2, 7 Town Members at £2, 14 Country Members at £1	36 0 0	
for 1917, 42 Fellows at £2, balance 1 Fellow at £1, 18s. 6d., 45 Town Members at £2, 84 Country Members at £1	259 18 6	
for 1918, 1 Fellow at £2, 3 Country Members at £1, part 1 Country Member at 2s.	5 2 0	
for 1919, part 1 Fellow at £1	1 0 0	
		304 0 6
„ Entrance Fees, to be put to Capital ..		8 0 0
„ Life Membership Subscription, to be put to Capital		15 0 0
„ Sale of Publications to Government		100 0 0
„ Sale of Publications otherwise		15 14 2
„ Sales of extra Reprints of Papers		33 6 9
„ Government Grant, 1917–8		300 0 0
„ Interest on Fixed Deposit at Standard Bank		32 0 0
„ Interest on money formerly in Post Office Savings Bank, to date of closing account		16 15 11
		£824 17 4

Expenditure.

	£ s. d.	£ s. d.
By Publications		315 13 9
„ Landing Charges, etc...		3 19 1
„ Research Grants :		
Payment of Grants	165 0 0	
Expenses in Advertising	5 1 9	
		170 1 9
„ Cost of Stamps on retaining £800 for one year on Fixed Deposit at Standard Bank		0 4 0
„ Compilation for International Scientific Catalogue of Papers		25 0 0
„ Clerical Assistance and Work in Library ..		55 0 0
„ Local Printing and Stationery		29 10 6
„ Postages and Petties		33 4 2
„ Bank Charges for Commissions, Ledger Fees, etc.	3 3 9	
less Commissions paid by Members ..	1 13 9	
		1 10 0
„ Hire of Rooms for Meetings, Caretaker, 1917		5 15 6
„ Insurance of Library, Premium 1917–8 ..		0 5 6
„ Purchase of Books for Library		2 10 0
„ Balance, being excess of Revenue over Expenditure		182 3 1
		£824 17 4

ASSETS AND LIABILITIES AS AT DECEMBER 31, 1917.

Assets.*

	£	s.	d.
Money at Standard Bank on Fixed Deposit at 4½ per cent...	800	0	0
Money in Savings Bank Department of Standard Bank (Life Subscriptions and Entrance Fees)	167	0	0
Union of S. Africa 5 per cent. Stock (1921–36)	400	0	0
Balance at Standard Bank as per Pass Book	109	19	7
Arrears of Subscriptions, as in Statement for 1916, due at beginning of 1917, £76, less £37 paid in year and £26 struck off as irrecoverable	13	0	0
Arrears of Subscriptions for 1917	36	18	6
	£1526	18	1

Liabilities.

		£	s.	d.
Subscriptions, whole or in part, received for 1918, 1919 ..		6	2	0
Research Grants unpaid, whole or in part :				
Miss M. Wilman (1914)	£25			
Professor J. T. Morrison (1917)	£100			
Professor S. J. Shand (1917)	£35			
		160	0	0
Binding Proceedings of Royal Society of London		9	0	0
Earmarked for Expense of Publishing, as a part of the Transactions, a reproduction of a Bushman Painting (Council Minutes, May 12, 1915) a sum not exceeding		350	0	0
Balance from 1912 Conversazione carried forward towards the expenses of future Conversazione in Cape Town ..		7	4	0
Capital at December 31, 1917, being excess of Assets over Liabilities		994	12	1
		£1526	18	1

* Exclusive of value of library and publications of the Society held in stock.

We hereby certify that we have examined the above balance and revenue account with the books, vouchers, and Banker's pass book relating thereto, and that in our opinion they correctly set forth a true and correct statement of the affairs of the Society.

J. HALM.
CHAS. F. JURITZ.

NOTE.—Accounts for some printing ordered in 1917 have not yet been received.

ORDINARY MEETING.

An Ordinary Meeting was held after the Anniversary Meeting.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

The Minutes of the last Ordinary Meeting were confirmed.

Professor R. W. WILCOCKS and Mr. L. P. BOSMAN were elected Members.

The following were nominated for membership :—Mr. R. W. E. TUCKER, Mr. G. A. H. BEDFORD, Dr. MELLE, Mr. P. v. D. RIET COPEMAN, and Mr. W. J. COPENHAGEN.

Mr. A. L. HALL was received as a Fellow.

An Ordinary Meeting was held on Wednesday, April 17, 1918, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Mr. R. W. E. TUCKER, Mr. G. A. H. BEDFORD, Dr. MELLE, Mr. P. v. D. RIET COPEMAN, and Mr. W. J. COPENHAGEN were elected Members.

Dr. M. R. DRENNAN, proposed by Dr. J. D. F. GILCHRIST, seconded by the Hon. Secretary, and Dr. CORNELIS PIJPER, proposed by Miss M. WILMAN, seconded by Mr. J. R. SUTTON, were nominated for membership.

Sir A. THEILER and Dr. J. MOIR were received as Fellows.

The following communications were made :—

" Luminosity in a South African Earthworm and its Origin," by J. D. F. GILCHRIST.

Luminous earthworms are found on the slopes of Table Mountain. The luminosity proceeds from a discharge from the mouth and anus which consists of cells heavily laden with inclusions of different kinds. The smaller inclusions consist of a substance allied to fat, by the oxidation of which the light is produced. The cells arise from the body cavity and are discharged into the anterior and posterior parts of the alimentary canal by definite communications between the coelom and alimentary tract.

" Note on the Adjugate of Bezout's Eliminant of Two Binary Quantics," by Sir THOMAS MUIR.

" On the Genera Diplocystis and Broomeia," by I. B. POLE-EVANS and AVERIL M. BOTTOMLEY.

Some specimens of Diplocystis have recently been obtained by the

authors from Portuguese East Africa, and this is the first recorded occurrence of the interesting germs from Africa. The African material is not identical with that from Cuba, and the authors describe it as Diplocystis Junodii (*nov. sp.*).

"South African Perisporiaceae: II. Revisional Notes," by ETHEL M. DOIDGE.

This communication consists of a revision, due to work on a number of fresh collections of South African Perisporiaceae, of a previous communication on the subject by the author.

"Fresh-water Snails as a Cause of Parasitic Diseases," by F. G. CAWSTON.

The author describes a number of snails collected by him from various districts in South Africa and found to be infested with the cercarial stages of the various trematode worms.

"Colour and Chemical Constitution. Part IV.: The Remaining Phthaleins," by JAMES MOIR.

The absorption-spectra of complex Phthaleins are described, these being partly duplex compounds of the phenol-anthrol type and partly of a new class (*e.g.* thymol-naphthol) derived from thymoylbenzoic acid. The additive nature of the effects of different substitutions is emphasised by means of a table giving the numerical values of the change of wave-length for different substituting groups.

An Ordinary Meeting was held on Wednesday, May 15, 1918, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Dr. M. R. DRENNAN and Dr. CORNELIS PIJPER were elected Members.

Mr. G. J. HARKINS, proposed by Dr. L. PÉRINGUEY, seconded by the Hon. Secretary, and Dr. L. J. KRIGE, proposed by Mr. J. S. v. D. LINGEN, seconded by the Hon. Secretary, were nominated for membership.

Mr. C. W. MALLY was received by the President as a Fellow.

The Hon. Secretary announced the names of the following members who are candidates for Fellowship:—ALEXANDER BROWN, proposed by J. C. BEATTIE, J. T. MORRISON, H. BOHLE, A. OGG; Miss ETHEL MARY DOIDGE, proposed by A. W. ROGERS, A. L. HALL, I. B. POLE-EVANS, J. C. BEATTIE; HAROLD BENJAMIN FANTHAM, proposed by J. C. BEATTIE, E. T. MELLOR, I. B. POLE-EVANS, A. W. ROGERS; SIDNEY H. HAUGHTON, proposed by

A. W. ROGERS, R. B. YOUNG, A. L. HALL, C. F. JURITZ, J. D. F. GILCHRIST; ANDREW YOUNG, proposed by P. A. WAGNER, A. L. DU TOIT, R. B. YOUNG, C. F. JURITZ.

The President announced his nomination of Dr. A. JASPER ANDERSON and Dr. G. S. CORSTORPHINE as Vice-Presidents.

The following communications were made —

" South African Perisporiaceae: III. Notes on Four Species of Meliola hitherto unrecorded from South Africa," by ETHEL M. DOIDGE.

The fungi considered in the paper are all from Natal and the eastern part of the Cape Province, and have been identified from recent collections.

" Reproduction of Fishes in Table Bay," by J. D. F. GILCHRIST.

The eggs and young of twenty-one species of fishes were procured in about sixty tow-nettings made at more or less regular intervals throughout the year. Fourteen of these were referred to known species. The eggs procured and larvæ hatched from them are described and figured. The eggs of the sardine (Sardina sagax) and of the anchovy (Engraulis capensis) indicate that these fish are present in abundance, though as yet not utilised for economic purposes.

" Note on the Electrogram of the Medulla Oblongata," by W. A. JOLLY.

An Ordinary Meeting was held on Wednesday, June 19, 1918, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Mr. G. J. HARKINS and Dr. L. J. KRIGE were elected Members.

Professor W. B. M. MARTIN, M.D., Professor T. J. MACKIE, M.D., and Dr. E. S. COGAN were nominated for membership.

Exhibitions :—

Mr. S. H. HAUGHTON exhibited two skulls of a new form of carnivorous Therapsid (Reptilia) from the Lower Beaufort Beds. The relationships with the known families, and the differences from them, were discussed, and the form—for which the name *Whaitsia platycops* was proposed—was shown to belong to a new family, which may be called the *Whaitsidae*.

Dr. L. PÉRINGUEY exhibited some Bushman paintings on stones, found in the cave shelters of Plettenberg Bay, and mostly executed in black, black and white, and red ochre. Hitherto only parietal, *i.e.* paintings on walls or roofs of shelters, have been recorded. In the present instances, however,

the paintings are on flat detached fragments of quartzite, some thin, others thicker; occasionally there is a convex one, and in some cases the continuation of the painting is to be observed on the cleft or side part; the blocks sometimes bear paintings on both faces. The subjects are animals, rendered with the well-known accuracy of the San; and human, somewhat conventional, figures, running, dancing, struggling, etc. The technique is that obtaining in the Lange Kloog (George), but one of these paintings represents men with tattoo-marks, bearded, and with either tousled hair or head-dresses, reminding one of the attitude and appearance of the Lybians decorating the tomb of the Egyptian King Seti the 1st and other Egyptian delineations.

We now know that some such paintings were used by the Strand Loopers as a kind of votive offering, and placed over the tucked-up body in rock-shelters of the littoral, filled almost to the roof with broken and partly pulverised shells, *débris de cuisine*, etc. Some of these shelters are partially filled with stalactite columns formed after the filling of the cave, because the stalagmite rests on the debris, and it is under the edge of such a column that one of the paintings was found. This fact postulates a certain antiquity, the more so that the soil from which the stalactite formation is derived is very poor in lime.

Judging from the relics of their industry, as revealed in these sepultures, the Strand Loopers were in the age of stone and bone combined, and their technique is of the most primitive kind, as revealed by the implements and tools exhibited.

The art of painting, more than the difference in language, divides the Hottentot from the Bushman. The former (Khoi Khoi) does not paint; the Bushman (San) does. The Hottentot is a comparatively late-comer, for the Bushman has never reproduced, except quite lately, the long-horned ox and the fat-tailed sheep, which the Khoi Khory brought with him to South Africa.

The following communications were made :—

"A Note on the Possibility of Long-range Weather Forecasts," by J. R. Sutton.

The author shows that the June temperatures, and especially the minima, at Kimberley are modified by the character of the May rainfall.

"South African Perisporiaceae: IV. New Species from the Coast Districts."

Nine new species are described of fungi belonging to the Perisporiaceae; of these six belong to the genus *Meliola*, two to the genus *Zukalia*, and one to the genus *Phaeodimeriella*; these were all collected in different localities near the coast in the Cape Province, Natal, Zululand, and Portuguese East Africa.

"Preliminary Note on Anatase," by J. S. v. d. Lingen and A. R. E. Walker.

The authors gave a preliminary account of their investigations on the radiation pattern of Anatase.

An Ordinary Meeting was held on Wednesday, July 17, 1918, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. A. Jasper Anderson, Vice-President, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

The Society, on the motion of the Vice-President, recorded its profound sympathy with Mr. S. S. Hough on the death of Mrs Hough, and its sense of the deep loss which the community has sustained in the loss of one who took so active a part in its life.

Professor W. B. M. Martin, Professor T. J. Mackie, and Dr. E. S. Cogan were elected members.

Dr. E. R. Montgomery and Mr. W. F. Schlupp were nominated for membership.

The following communications were made :—

"On the Electrostatic Deflection in a Cathode Ray Tube," by A. Ogg, F.R.S.S.Af.

In the ordinary Thomson cathode ray tube for determining the value of e/m for cathode rays, we have to allow for the irregularity of the electrostatic field near the edges of the charged plates. It is interesting to find the electrostatic deflection when the rays are projected parallel to the plates but at some distance from them. The author gives methods for making the calculation.

"Note on a Disease in the Snoek (Thyrsites Atun)," by J. D. F. Gilchrist, *P*.R.S.S.Af.

The snoek, one of the most important Cape fishes from an economic point of view, is well known to be found frequently in a "pap" or soft condition. This is attributed by the fishermen to the fact that it has not been properly killed on capture, the consequence being that it struggles about in the bottom of the boat, and, in doing so, bruises the flesh to such an extent as to produce the condition mentioned. This condition may occur a few hours after the fish has been caught, and may quickly become so marked that the whole of the muscles, especially of the back, appear quite soft and liquid. The process is believed to be totally distinct from decay by putrefaction or by softening of the flesh by exposure to the heat

of the sun, which also frequently occurs. As it was suspected that this condition might be brought about by the presence and rapid multiplication of some Protozoal parasite in the muscles, the diseased tissue was examined microscopically, and after staining with methylene blue and other reagents, the presence of very numerous sporelike bodies was detected. These were all arranged in groups of fours, and occasionally, on fixation by heat, long filaments were shot out from them, showing that they were Protozoa belonging to the group of Cnidosporidia, which are known to produce diseased conditions in the muscular and other tissue of fish. The groups of four bodies with filaments suggest the family of the Chloromyxidae with their four polar capsules, but there is reason for believing that they represent spores, not polar capsules, and if so they probably belong to a new form of the Microsporidia.

" Mycological Notes I.," by Miss Ethel M. Doidge.

An Ordinary Meeting was held on Wednesday, August 21, 1918, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Dr. E. R. Montgomery and Mr. W. F. Schlupp were elected Members.

Dr. W. E. de Korte and Professor G. H. Stanley were nominated for membership.

The following communications were made :—

" On the Velocities of Two Distinct Groups of Secondary Corpuscular Rays produced by a Homogeneous Röntgen Radiation and their Absorption Coefficients in Gases," by Lewis Simons.

The absorption coefficients in gases of the secondary corpuscular rays produced by the incidence of silver X-rays on a single gold leaf were found by calculation from the pressure at which the cathode ionization falls to half its maximum value. They are probably too high for the fastest corpuscles produced.

The log. cathode ionization curves could be analysed into two distinct portions when the particles emerge from a very thin screen, giving two absorption coefficients in a gas, their ratio being 1 : 4·76.

The maximum velocity of emergence of the slower corpuscle was calculated from

$$\tfrac{1}{2}mv^2 = {}_{ag}h\nu_{k} - ({}_{au}h\nu_{L} + h\nu_{M} + \text{etc.}),$$

which gives a value 65×10^8cm./sec., and therefore since $\lambda v^4 = \text{const.}$, the velocity of the faster corpuscle $= 96 \times 10^8$cm./sec. The mean value of the velocity of the parent cathode particle producing silver X-rays calculated from the results of Rutherford, Barnes, and Richardson, and from Duane and Hunt, and from $\frac{1}{2}mv^2 = {}_{a_7}hv_K$ is $96 \cdot 5 \times 10^8$ cm./sec.

"On a New Lizard of the Genus Latastia from Southern Rhodesia," by G. A. Boulenger.

"On Rana Ornatissima and Rana Ruddi," by G. A. Boulenger.

"On a Nematode of Fowls having a Termite as an Intermediate Host," by Sir A. Theiler.

Some time ago a farmer forwarded a species of termites infected with a nematode, inquiring whether these worms were a stage in the life cycle of the wire worm of sheep (*Haemonchus contortus*). This possibility, of course, had to be excluded, but since they were larvae, it was concluded that they represented a stage in the life cycle of a nematode, which had its habitat in a host that would consume termites. Many birds are known to eat termites; fowls are particularly fond of them. It was decided to feed infected termites as well as the larvae extracted from them. For this purpose eggs were hatched in an incubator and the chickens reared under conditions excluding accidental infection. Infected termites were found on red soil in the neighbourhood of a kaffir kraal. A series of experiments were carried out, and in every instance an imago was so obtained in the small intestines of the fowls. The control fowls were free of it, as well as controls running in an area not inhabited by the species of termites. The imago was identified as a Filaria, and since it turned out to be a new species, the name *Filaria gallinarum* is proposed. According to Maupas, free-living nematodes undergo four different ekdyses to reach the mature stage. This applies also to the half-parasitic nematodes (e.g. *Ankylostoma duodenale*, *Haemonchus contortus*, *Trichostrongylus douglasii*). These stages could not be definitely traced in the cycle of *Filaria gallinarum*. The first ekdysis was found in the termite. The second ekdysis does not take place there, as could be expected. Two stages were found in the fowl. It is thus possible that only three ekdyses are present, the second one being suppressed, not being necessary as in the case of half-parasitic nematodes in which the larva after having undergone the second ekdysis is enclosed in a skin that protects it against external influences until it has been picked up by the host. The infected termite is known as the houtkopper, and was identified by Fuller as *Hodotermes Pretoriensis*. It is of interest to note that only workers are infected, thus supporting the view that the food of the two types of termites is different.

"Note on Recurrents resolvable into a Sequence of Odd Integers," by Sir Thomas Muir.

"Meliolaster: a New Genus of the Microthyriaceae," by Miss E. M. Doidge.

A fungus, occurring on *Piper capensis*, is described, which combines certain characters of the genera *Meliola* and *Asterina*.

Annual Meeting.

The Annual Meeting was held on Wednesday, September 25, 1918, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

The following were elected Fellows:—Alexander Brown, M.A., B.Sc., proposed by J. C. Beattie, J. T. Morrison, H. Bohle, and A. Ogg; Ethel Mary Doidge, M.A., D.Sc., proposed by Arthur W. Rogers, A. L. Hall, I. B. Pole-Evans, and J. C. Beattie; Sidney H. Haughton, B.A., proposed by Arthur W. Rogers, Robert B. Young, A. L. Hall, Chas. F. Juritz, and J. D. F. Gilchrist; Harold Benjamin Fantham, M.A., D.Sc., proposed by J. C. Beattie, Edw. T. Mellor, I. B. Pole-Evans, and Arthur W. Rogers; Andrew Young, M.A., D.Sc., proposed by Percy A. Wagner, Alex. L. du Toit, Robert B. Young, and Chas. F. Juritz.

An Ordinary Meeting (postponed on account of the epidemic prevailing at the time) was held on Wednesday, October 30, 1918, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

Business:—

The Minutes of the previous Meeting were confirmed.

Dr. W. E. de Korte and Professor G. H. Stanley were elected Members.

Professor D. Thoday was proposed for membership by the Hon. Treasurer, seconded by the Hon. General Secretary.

The Chairman gave notice of the election of the Council, President, and Officers, and announced the Council's recommendation to the Society as Members of Council for 1919 of the following seven Members of the existing Council: J. C. Beattie, L. Crawford, J. D. F. Gilchrist, W. A. Jolly, J. Moir, I. B. Pole-Evans, and Sir Arnold Theiler; with the following five additional Fellows: C. W. Mally, J. T. Morrison, C. E. Moss, A. Ogg, and G. W. Robertson.

The Council further recommend J. D. F. GILCHRIST as President, L. CRAWFORD as Hon. Treasurer, and W. A. JOLLY as Hon. General Secretary.

The following communications were made :—

"Haemolysis by Serum in Combination with Certain Benzol Bodies," by T. J. MACKIE.

It has been shown that while serum-complement acts as haemolysin in the presence of a specific immune body, and also along with colloidal silicic acid, serum is also capable of producing lysis of red blood corpuscles which have been treated with certain benzol bodies. The paper records the result of experiments carried out with brilliant green.

"A Possible Lunar Influence upon the Velocity of the Wind at Kimberley," by J. R. SUTTON.

The object of this paper is to discuss the question whether there is a lunar term in the velocity of the wind at Kimberley. The results of hourly observations made during 180 lunations reveal only one definite maximum and minimum of velocity in the lunar curve, the former falling about three hours before lunar midnight, the latter just before lunar noon ; the range being ·20 miles an hour. When the moon is in south declination, the maximum of velocity is near lunar noon and the minimum near lunar midnight ; the opposite being the case when the moon is north ; the respective ranges of velocity being ·32 and ·55 miles an hour, which are greater than one would have expected to find.

"South African Perisporiaceae : V. Notes on an Interesting Collection from Natal," by Miss ETHEL M. DOIDGE.

A number of leaf fungi are described from Natal, chiefly belonging to the genus Meliola, and including hitherto undescribed species.

"Fusion of Karroo Grits in Contact with Dolerite Intrusions," by ANDREW YOUNG.

Certain unusual contact alterations occurring in the Heilbron district were described. Dolerite intrusions have apparently fused the Karroo sandstone or grit to a dark glass resembling pitchstone. The contacts are sharply defined, and the vitrification extends to a distance of several yards from the actual contact plane. The results of a detailed petrological examination of the dolerite, the glass, and the sandstone were described. The dolerite presents no abnormal features. The sandstone contains much soda felspar. The glass on analysis yields about 7 per cent. of soda and about 5 per cent. of combined water. The glass might thus be called a pitchstone. Microscopic examination of the glass shows the presence of microlites of cordierite, magnetite, and also a fibrous mineral with physical properties suggestive of an amphibole. These microlites seem to be practically identical with those described by Harker and Clough as occurring under somewhat similar circumstances in the island of Soay near Skye.

"On Hyalite," by J. S. v. d. Lingen and A. R. E. Walker.

The points of resemblance between hyalite and liquid spherulites are noted. The truth of the statement that liquid spherulites and, under certain conditions, hyalite give uniaxial figures when examined in convergent polarised light is questioned.

"On Anatase," by J. S. v. d. Lingen and A. R. E. Walker.

The authors exhibited a Laue radiograph of Anatase which shows that, according to the usual interpretation of such a photograph, the mineral possesses full tetragonal symmetry.

Herbert Smith and W. von Bonde have, independently, suggested that possibly it did not possess the full degree of symmetry usually assigned to it; in both cases this suggestion was based on a study of the external crystal form of the mineral.

"On Radioactive and other Minerals associated with Fossil Wood from the Beaufort Series," by A. R. E. Walker.

A description is given of torbernite and a mineral allied to uranocircite occurring, associated with calcite and barytes, encrusting and impregnating fossil wood from beds of Lower Beaufort age on the farm Quaggasfontein.

"On Tantalite Crystals from Namaqualand," by A. R. E. Walker.

A description is given of a number of crystals obtained from a tantalite prospect at Jakals Water, Namaqualand.

The collection represents specimens which, solely because they possessed crystal faces, .were set aside during the sorting of tantalite from debris obtained by blasting.

Apparently two distinct varieties of tantalite are represented which, whilst exhibiting a general similarity of crystal form, consistently differ from each other in certain crystallographic details, in specific gravity and other physical characters, and, presumably, in chemical composition.

Attention is drawn to the fact that, if the form *u* (133) occurring on the crystals of tantalite be regarded as the unit pyramid (111), this would accordingly necessitate turning the crystals round their vertical axes through 90 degrees in order to read them correctly as orthorhombic crystals.

If that be done, the crystals of tantalite exhibit not only a very close resemblance in form and habit to the figured crystals of Polycrase and Euxenite, but the crystallographic angles also approximate very closely to those recorded for both Polycrase and Euxenite.

Polycrase and Euxenite are niotates and titanates of yttrium, erbium, cerium, and uranium, and it is suggested that they may be isomorphous with tantalite, and that the intergrowth of very minute quantities of these minerals with the tantalite may account for the radioactivity of the latter mineral.

"Colour and Chemical Constitution," by James Moir.

Part V. The Yellowness of Certain Phthaleins when Acid.

Phenolsulphonephthalein, on account of its high ionization, does not form a colourless ring-lactone like phenolphthalein, but remains yellow when acidified: it is really the orthosulphonic acid of benzaurine (which shows similar colour changes). Benzaurine parasulphonic acid and benzaurine-carboxylic methylester ("phenolphthalein methylester") have now been made and found to possess the same property of yellowness in acid solution, lactone-formation being excluded in both cases. The latter substance is coloured pink by bicarbonates, and not bleached by excess alkali.

Part VI. The Ultra-violet Spectra of the Phthaleins.

A discussion of Howe and Gibson's discovery of violet and ultra-violet absorption-bands in alkaline phthaleins. These have frequencies which are $1\frac{1}{2}$ times and twice those of the visible band. It follows that the fundamental vibration of alkaline phenolphthalein is still unobserved, being in the infra-red at λ 11,090 (frequency 9·02) on the usual scale. The visible band in the green is its 1st harmonic, and the other two are its 2nd and 3rd. The bands of phthaleins in H_2SO_4 solution described in Part I. (1917) are due to the violet 2nd harmonic "loaded" with H_2SO_4 and so brought up into the green. Similar "loading" effects are observable in other heavy solvents. If y is the visible H_2SO_4 frequency, and x is the violet alkali frequency, then the law $y=x-7$ holds for all the phthaleins, the constant 7 representing the molecular volume of H_2SO_4.

Part VII. Inorganic Phenomena in connection with Cobalt, Nickel, Manganese, and Uranium.

Part VIII. Fluorescence and its Laws.

On comparsion of the spectra of dissolved (ionized) salts of these metals with those of the salts in the solid state, "loading" effects are observed similar to those shown by the phthaleins. The formation of blue cobalt compounds is ascribed to considerable increase of molecular weight due to combination with envjironing molecules. In the case of cobalt halides the wave-lengths appear to be proportional to the eighth root of the molecular weight, and in uranyl compounds they are proportional to the sixth root. The coincidence of these numbers with the periodic place of the element is noted.

Solid uranyl compounds fluoresce, and the emission-spectrum shows 4 or 5 bands which are the absorption-bands of the same substances moved up from the blue into the green. The general law $\lambda_1=0{\cdot}145\lambda^{\frac{1}{3}}$ expresses the change of wave-length from absorption to fluorescence-emission; thus an absorption-band at λ499 in any of these solid fluorescent substances is accompanied by a fluorescent band at λ574, which agrees with the above formula. This relationship between cube of fluorescent wave-length and

fourth-power of absorption wave-length appears to hold for other fluorescent substances as well as for uranium compounds.

ANNIVERSARY MEETING.

The Anniversary Meeting of the Society was held on Wednesday, March 19, 1919, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

The Report of the Hon. General Secretary was submitted and adopted.

The Report of the Hon. Treasurer was submitted and adopted.

Dr. L. PÉRINGUEY moved that the Government should be approached and requested to appoint the President of the Royal Society as a member *ex officio* of the Research Grant Board. The motion was seconded by Dr. A. MARIUS WILSON and agreed to.

The Meeting also recommended that steps should be taken to have the grant which the Society receives from Government increased.

The following were elected Members of the Council for the year 1919:—

Dr. J. C. BEATTIE.	Dr. J. T. MORRISON.
Dr. L. CRAWFORD.	Dr. C. E. MOSS.
Dr. J. D. F. GILCHRIST.	Dr. A. OGG.
Dr. W. A. JOLLY.	Mr. I. B. POLE-EVANS
Mr. C. W. MALLY.	Dr. G. W. ROBERTSON.
Dr. J. MOIR.	Sir ARNOLD THEILER.

Dr. J. D. F. GILCHRIST was elected President.

Dr. L. CRAWFORD, Hon. Treasurer.

Dr. W. A. JOLLY, Hon. General Secretary.

ORDINARY MEETING.

An Ordinary Meeting was held after the Anniversary Meeting.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

The Minutes of the last Ordinary Meeting were confirmed.

Professor D. THODAY was elected a Member.

The following were nominated for membership:—Mr. W. H. ADDISON, Mr. HERCULES SIMPSON, and Mr. J. PARRY, proposed by Dr. J. R. SUTTON, seconded by Miss WILMAN; Mr. RUPERT W. JACK, F.E.S., proposed by Mr.

C. P. Lounsbury, seconded by Mr. C. W. Mally; Dr. Ernest Anderson, Ph.D., proposed by Mr. C. P. Lounsbury, seconded by Mr. C. K. Brain; Mr. G. G. Holmes, proposed by Dr. A. Young, seconded by the Hon. General Secretary.

An Exhibition was made by Mr. J. Steph. v. d. Lingen of photographs of a kiepersol growing in a wild olive tree.

The photographs show different aspects of the junction of the stem of the kiepersol and the wild olive. No traces of the roots of the former are visible on the bark. The kiepersol measures about 2½ feet, and has maintained this height for the past thirty years. The locality is Wittekopjes, Dist. Vredefort, O.F.S.

The following communications were made :—

" Some Notes of a Visit to Lake Fundusi in the Zoutpansberg District of the Transvaal," by T. G. Trevor, communicated by Dr. Roger.

" Note on the so-called Second Branchial Arch in Lizards," by John Hewitt.

" Note on Unimodular and other Persymmetric Determinants," by Sir Thomas Muir.

" Note on Certain Determinant Identities arrived at by H. v. Koch," by Sir Thomas Muir.

Report of the Hon. General Secretary for the Year ending December 31, 1918.

Seven Ordinary Meetings, the Annual Meeting, and the Anniversary Meeting were held during the year, and the following papers were read :—

" Luminosity in a South African Earthworm and its Origin," by J. D. F. Gilchrist.

" Note on the Adjugate of Bezout's Eliminant of Two Binary Quantics," by Sir Thomas Muir.

" On the Genera Diplocystis and Broomeia," by I. B. Pole-Evans and Averil M. Bottomley.

" South African Perisporiaceae : II. Revisional Notes," by Ethel M. Doidge.

" Fresh-water Snails as a Cause of Parasitic Diseases," by F. G. Cawston.

" Colour and Chemical Constitution. Part IV. : The Remaining Phthaleins," by James Moir.

" South African Perisporiaceae : III. Notes on Four Species of Meliola hitherto unrecorded from South Africa," by Ethel M. Doidge.

" Reproduction of Fishes in Table Bay," by J. D. F. Gilchrist.

" Note on the Electrogram of the Medulla Oblongata," by W. A. Jolly.

"A Note on the Possibility of Long-range Weather Forecasts," by J. R. Sutton.

"South African Perisporiaceae: IV. New Species from the Coast Districts," by Ethel M. Doidge.

"Preliminary Note on Anatase," by J. S. v. d. Lingen and A. R. E. Walker.

"On the Electrostatic Deflection in a Cathode Ray Tube," by A. Ogg.

"Note on a Disease in the Snoek (Thyrsites Atun)," by J. D. F. Gilchrist.

"Mycological Notes I.," by Ethel M. Doidge.

"On the Velocities of Two Distinct Groups of Secondary Corpuscular Rays produced by a Homogeneous Röntgen Radiation and their Absorption Coefficients in Gases," by Lewis Simons.

"On a New Lizard of the Genus Latastia from Southern Rhodesia," by G. A. Boulenger.

"On Rana Ornatissima and Rana Ruddi," by G. A. Boulenger.

"On a Nematode of Fowls having a Termite as an Intermediate Host," by Sir A. Theiler.

"Note on Recurrents resolvable into a Sequence of Odd Integers," by Sir Thomas Muir.

"Meliolaster: a New Genus of the Microthyriaceae," by Ethel M. Doidge.

"Haemolysis by Serum in Combination with Certain Benzol Bodies," by T. J. Mackie.

"A Possible Lunar Influence upon the Velocity of the Wind at Kimberley," by J. R. Sutton.

"South African Perisporiaceae: V. Notes on an Interesting Collection from Natal," by Ethel M. Doidge.

"Fusion of Karroo Grits in Contact with Dolerite Intrusions," by Andrew Young.

"On Hyalite," by J. S. v. d. Lingen and A. R. E. Walker.

"On Anatase," by J. S. v. d. Lingen and A. R. E. Walker.

"On Radioactive and other Minerals associated with Fossil Wood from the Beaufort Series," by A. R. E. Walker.

"On Tantalite Crystals from Namaqualand," by A. R. E. Walker.

"Colour and Chemical Constitution. Part V.: The Yellowness of Certain Phthaleins when Acid; Part VI.: The Ultra-violet Spectra of the Phthaleins; Part VII.: Inorganic Phenomena in connection with Cobalt, Nickel, Manganese, and Uranium; Part VIII.: Fluorescence and its Laws," by James Moir.

The Society has awarded, on the recommendation of the General Committee, for Grants-in-Aid of Research, the following grants: £40 to

Professor M. Rindl for continuation of investigation of the active principles of toxic and medicinal indigenous plants; £100 to Mr. J. S. v. d. Lingen for continuation of researches in Radiology and Crystallography; £40 to Mr. C. B. Hardenberg for a study of the family Psychidae and other Lepidoptera; £40 to Mr. S. H. Haughton for investigation of the vertebrate and invertebrate fauna of the Stromberg Beds, mainly in the north-eastern portion of the Cape Colony; £40 to Mr. R. W. E. Tucker for the study and collection of the Arachnid fauna in the Eastern Transvaal, Lydenburg District, Selati Region.

Vol. VI., part 2, and Vol. VII., parts 1 and 2, of the Society's Transactions have been issued during the year.

The number of Honorary Fellows is 3, Fellows 54, Members 169.

The Society regrets to have to record the death since the 1918 Anniversary Meeting of G. S. Corstorphine, Fellow and former Vice-President; G. H. H. Fincham, Member; C. Friedlander, Member; L. H. Walsh, Lieut., London Regiment, M.C., D.C.M., Member on Active Service; A. E. V. Zealley, Member. One Fellow and five Members have resigned.

TREASURER'S ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1918.

Revenue.

	£ s. d.	£ s. d.
To Subscriptions received in 1918 :		
for 1917, 2 Fellows at £2, 3 Town Members at £2, 10 Country Members at £1, balance 1 Country Member at 18s. 6d.	20 18 6	
for 1918, 42 Fellows at £2, 41 Town Members at £2, 82 Country Members at £1, balance 1 Country Member at 18s., £1 extra Subscription from Country Member elected Fellow	249 18 0	
for 1919, 1 Fellow at £2, part 1 Town Member at 2s., 4 Country Members at £1	6 2 0	
		276 18 6
,, Entrance Fees		15 0 0
,, Life Membership Subscription, Fellow ..		25 0 0
,, Sale of Publications to Government.. ..		100 0 0
,, Sale of Publications otherwise, less refund of Copies returned		20 17 3
,, Sale of extra Reprints of Papers		8 8 9
,, Government Grant, 1918–9		300 0 0
,, Interest on Fixed Deposit at Standard Bank		34 0 0
,, Interest on £400 Union of South Africa 5 per cent. Stock		19 12 8
,, Interest on money in Savings Bank Department of Standard Bank		5 17 4
,, Excess of Expenditure over Revenue ..		105 19 9
		£911 14 3

Expenditure.

	£ s. d.	£ s. d.
By Publications		550 0 0
,, Research Grants :		
Payments of Grants	200 0 0	
Expenses in Advertising..	5 15 3	
		205 15 3
,, Cost of Stamps on retaining £800 for one year on Fixed Deposit at Standard Bank		0 4 0
,, Compilation for International Scientific Catalogue of Papers		25 0 0
,, Clerical Assistance and Work in Library ..		55 0 0
,, Local Printing and Stationery		39 15 6
,, Postages and Petties		17 10 0
,, Bank Charges for Commissions, Ledger Fees, etc.	3 12 9	
less Commissions paid by Members ..	1 14 9	
		1 18 0
,, Hire of Room for Meetings, Caretaker, 1918		6 6 0
,, Insurance of Library, Premium 1918–9 ..		0 5 6
,, Binding Periodicals in Library..		10 0 0
		£911 14 3

ASSETS AND LIABILITIES AS AT DECEMBER 31, 1918.

Assets.*

		£	s.	d.
Money at Standard Bank on Fixed Deposit at $4\frac{1}{2}$ per cent. (of which £207 is Life Subscriptions and Entrance Fees)		800	0	0
Money in Savings Bank Department of Standard Bank		152	17	4
Union of South Africa 5 per cent. Stock (1921–36)		400	0	0
Balance at Standard Bank as per Pass Book		18	2	6
Arrears of Subscriptions, as in Statement for 1917, due at beginning of 1918, £49 18s. 6d., less £20 18s. 6d. paid in year and £11 struck off as irrecoverable		18	0	0
Arrears of Subscriptions for 1918		44	0	0
Amount due for Sales of Transactions and extra Reprints of Papers		9	8	9
		£1442	8	7

Liabilities.

		£	s.	d.
Subscriptions, whole or in part, received for 1919		7	2	0
Research Grants unpaid, whole or in part:				
Miss M. Wilman (1914)	£25			
Professor J. T. Morrison (1917)	£80			
Professor S. J. Shand (1917)	£35			
Mr C. B. Hardenberg (1918)	£40			
Professor M. Rindl (1918)	£40			
		220	0	0
Printing of Transactions, a sum not exceeding		131	19	1
Binding Periodicals in Library, a sum not exceeding		10	0	0
Account due for Local Printing, not rendered before end of year		2	7	6
Earmarked for Expense of Publishing, as a part of the Transactions, a reproduction of a Bushman Painting (Council Minutes, May 12, 1915) a sum not exceeding		350	0	0
Balance from 1912 Conversazione carried forward towards the expenses of future Conversazione in Capetown		7	4	0
Capital at December 31, 1918, being excess of Assets over Liabilities		713	16	0
		£1442	8	7

* Exclusive of value of library and publications of the Society held in stock.

We hereby certify that we have examined the above balance and revenue account with the books, vouchers, and Banker's pass book relating thereto, and that in our opinion they correctly set forth a true and correct statement of the affairs of the Society.

ALEX. L. DU TOIT.
LEWIS SIMONS.
February 7, 1919.

An Ordinary Meeting was held on Wednesday, April 16, 1919, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

The following were elected Members :—Mr. W. H. ADDISON, Mr. HERCULES SIMPSON, Mr. J. PARRY, Mr. RUPERT W. JACK, F.E.S., Dr. ERNEST ANDERSON, and Mr. G. G. HOLMES.

Demonstration :—

Dr. GILCHRIST exhibited some specimens of a large Cerianthid larva which he had found cast up on the beach at Muizenberg. They were spherical and about 15 mm. in diameter, and showed no trace of tentacles. Some of these, which had been reared to the tentaculate stage in the Government Marine Laboratory, were also exhibited.

The following communication was made :—

"Some Controversial Notes on the Diamond," by J. R. SUTTON.

This paper consists of notes and observations, in the course of which the author discusses the spontaneous breaking of diamonds and reaffirms his previous conclusions on the subject. It is claimed that there is no fundamental difference of process between the spontaneous breaking of a pure colourless crystal containing an inclusion of foreign mineral and that of opaque or clouded diamond. The probable derivation of distorted diamonds (pseudo-cleavage) from groups and clusters is also considered. The hardness of the diamond is generally overestimated.

An Ordinary Meeting was held on Wednesday, May 21, 1919, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

The Hon. General Secretary announced that ANNIE PORTER, D.Sc., F.L.S., is a candidate for Fellowship, proposed by E. WARREN, E. M. DOIDGE, ARTHUR W. ROGERS, B. DE ST. JEAN V. D. RIET, A. L. HALL, and ANDREW YOUNG.

The following communications were made :—

"Note on Coloration produced in Clay by Injured Roots of Pinus Pinea," by B. de St. J. v. d. Riet.

Instances were described in which vapours from injured roots of the stone pine produced, in warm sunshine, blue, green, and occasionally purple stains on soil and subsoil on occasions when excavations were made close to the tree.

The phenomenon had first been observed near Stellenbosch in March of this year, and subsequently also on the road between Camps Bay and Hout Bay. In both cases the soil was a decomposed granite, that at Stellenbosch being very thoroughly altered to a light clay containing about 60 per cent. of quartz fragments. Traces of sulphates, chlorides, and arsenates were present ; no copper or chromium could be detected by ordinary qualitative tests, the principal metals present being iron and aluminium.

The stains were insoluble in organic solvents, and were not easily affected by acids, but were rapidly decolorised by solutions of caustic alkalies.

It was found that cuttings from fresh roots of the stone pine readily produced a blue colour with the white Stellenbosch clay when fragments of the latter were placed close to the cuttings in warm sunshine. The colour appeared as a film on the surface of the clay and gradually extended inwards, the internal part being of green rather than blue tint in most cases. Contact of clay with root is not necessary, and the root fragments show colour on the clay, irrespective of the presence of bark.

The blue tint was also obtained when a drop of the pleasant-scented essence (distilled in steam from the roots) was placed in a test-tube along with the clay (separated from the latter by a plug of cotton-wool) and exposed to warm sunshine.

A faint blue tint was obtained on the clay in the dark in a thermostat at 40 degrees C., a bit of fresh root causing the colour to appear only after several days, whereas in sunlight a similar blue film appears within a couple of hours.

Roots of other pines (*pinaster* and *insignis*) were tried, and gave no sign of blue stains, or any tint, with the Stellenbosch clay, in spite of several trials in bright sunshine.

The author ascribed the phenomenon to : (1) oxidation of volatile matter given off by roots of *Pinus pinea* ; (2) the resulting oxidation products, or product, under favourable conditions reacting with iron salts in the clay (the well-known reaction between many phenolic carbon compounds and ferric salts) ; (3) the production of a kind of lake with aluminium compounds in the clay.

It was pointed out that guaiacum resin dissolved in alcohol readily

stains the Stellenbosch clay, producing a greenish tint at first, soon passing, in sunshine especially, to a blue colour. The same guaiacum solution gives a blue coloration with a dilute solution of mixed potash and iron alums.

A reddish loam near Stellenbosch which gives a purple coloration with stone pine roots in sunshine is similarly coloured by the guaiacum solution.

Further work was stated to be in progress, particularly with a view to ascertaining the chemical composition of the volatile substances given off by roots of the stone pine.

"Note on the Shells of Schizoderma Spengleri," by J. D. F. GILCHRIST.

Shells of the bivalve *Schizoderma* are found in abundance on the Muizenberg sands, and present the peculiarity that they are either whole or broken up into small fragments. This seems to be due to the fact that, when the living animal is cast up on the beach, it is seized by the gull (*Larus dominicanus*) and dropped from a height of twenty to thirty feet on the wet sand. This has the effect of causing both shells to open without injury, or one shell only is broken, rarely both. It was shown by experiment that this depends on how the shells fall.

"An Extreme Case of Microcephaly," by Dr. DRU-DRURY.

The author describes the skull of a Basuto woman, aged thirty-two, which is preserved in the Port Alfred Mental Hospital. The type of skull is long headed and narrow, with apelike protrusion of the jaws (thick-lipped in life). The nose was of medium breadth and the orbits unusually high. The cranial capacity is 340 c.c., which is much smaller than an average case of microcephaly.

An Ordinary Meeting was held on Wednesday, June 18, 1919, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

The following were nominated for membership :—Professor R. H. COMPTON, proposed by Professor D. THODAY, seconded by the Hon. Secretary; Mr. F. J. JANSENS, proposed by the Hon. Secretary, seconded by Mr. W. A. RUSSELL ; Mr. C. VON BONDE, proposed by Dr. J. D. F. GILCHRIST, seconded by the Hon. Secretary.

The following communications were made :—

"South African Microthyriaceae," by Miss ETHEL M. DOIDGE.

This group of fungi has been recently revised by Von Hohnel and Theissen and others, and the characters of the family *Microthyriaceae* more

clearly defined. A short account is given of the genera represented in South Africa, and descriptions of species in the Cryptogamic section of the Union Mycological Herbarium, Pretoria; these include 33 species belonging to the genus *Asterina*; *Asterinelea*, 4 species; *Lembosia*, 4 species; *Morenoella*, 2 species; *Englerulaster*, 3 species; and 1 species of each of the genera *Microthyrium*, *Seynesia*, *Morenoina*, *Meliolaster*; of these 30 are species hitherto undescribed.

These fungi are common in the more humid wooded districts; coinciding in distribution with the *Perisporiaceae*; and since no collections have yet been made in many promising localities, it is probable that the number of known species will be increased from time to time, and that other genera at present reported only from South America will be found to be represented in South Africa.

"Note on Carbolic Acid as a Fixative for Histological Preparations," by C. L. Herman.

Carbolic acid in 5 per cent. solution was found a most efficient fixative for histological purposes. It has been used since 1912 for all organs including the central nervous system.

For the thyroid gland it is especially good, as it gives thorough fixation of the colloid without shrinking or distortion.

It acts by precipitating the protein without, however, entering into combination with it.

It penetrates all tissues, especially the nervous tissue, rapidly, and fixes both the cytoplasm and the nucleus without distortion or alteration.

The optical differentiation becomes very good, and all cell structures are found well and clearly defined. Staining is facilitated, and all stains are readily taken up.

"A Contribution to the Study of the Diamond Macle, with a Note on the Internal Structure of Diamond," by J. R. Sutton.

The first part of this paper describes the aspect and characteristics of macles from various South African diamond mines, and gives statistics showing that the standard thickness to which macles tend to conform is almost exactly one-half that of the perfect octahedron standing upon an equal face. The so-called "twinning plane" is not necessarily a true plane at all, but rather an irregular surface. Bultfontein Mine is remarkable for the large number of irregular twins it produces and the small percentage of macles.

In the second part the author discusses the "grain" of diamonds, as revealed by broken macles and by broken simple crystals, in which the fracture lies in a dodecahedral plane of symmetry, and deduces therefrom the primary cubical structure. The points of agreement and disagreement with the structure deduced by Bragg (by means of X-ray research) are

indicated. Three orders of cleavage are shown, *i.e.*, parallel to the faces of the octahedron, cube, and rhombic dodecahedron, respectively.

An Ordinary Meeting was held on Wednesday, July 16, 1919, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

In the absence of the President, Dr. L. PÉRINGUEY was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

The following were elected Members :—Professor R. H. COMPTON, Mr. F. J. JANSENS, and Mr. C. v. BONDE.

The following communications were made :—

"Bushman Engravings," by Dr. L. PÉRINGUEY.

The author gave a preliminary account of his investigation of various Bushman Engravings, and discussed the theories which may be advanced as to their significance.

"Comparative Study of Certain Cranial Sutures in the Primates," by Dr. R. W. SHUFELDT.

This paper is based upon the examination and comparison of several thousand human skulls in the Collections of the Department of Physical Anthropology of the United States Natural History Museum and the entire collection of skulls of Primates in the Division of Mammals of the same Institution.

An Ordinary Meeting was held on Wednesday, August 20, 1919, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

The following were nominated as Members :—H. KRAMER, M.D. (Edin.), M.R.C.P.E., F.R.C.S. (Edin.), and S. F. SILBERBAUER, M.D., M.R.C.P.E.

The following communications were made :—

"Note on a Sum of Products which involves Symmetrically the *n*th Roots of 1," by Sir THOMAS MUIR.

"Note on Some Abnormalities in the Cape Crawfish (*Jasus lalandii*)," by C. v. BONDE.

The following peculiarities were observed among specimens procured for laboratory uses in the Zoological Department of the University of Cape Town :—

Some time ago a peculiar feature was observed on a male crawfish, and described in a paper to the Royal Society of South Africa by W. von Bonde, published in Vol. VII. part 2 (1918). In this specimen it was found that in addition to the normally developed male genital apertures occurring on the 5th pair of pereiopods there was also an abnormal aperture on the 4th pereiopod of the right side. On a dissection of the reproductive organs being made, it was found that the testis of the right side was longer and stouter than that of the left side, and that from the right vas deferens a duct was given off opening at the abnormal aperture above mentioned.

Recently the following four abnormalities were noticed :—

The first is of a similar nature to the one described above. In this case an examination of the external features of an adult female crawfish revealed the presence of only a single genital aperture situated on the 3rd walking leg of the left side. The specimen was then dissected with a view to finding the relation between the external and internal structure. The ovary of the left side was normally developed and was connected by means of an oviduct to the genital aperture of the left side. The right ovary, on the other hand, had a twisted appearance, and was somewhat smaller than the left one. There was no oviduct on the right side, so that the ova apparently all passed through the single genital aperture on the left side.

The abdominal appendages on the male crawfish usually lack the presence of the endopodite, and thus consist normally of a basal protopodite and a single leaf-like exopodite. With regard to these appendages an interesting abnormality was observed.

On the 5th segment of the abdomen the pleopod or swimmeret of the left side showed the peculiar development of a small leaf-like segment attached to the protopodite. From its situation on the proximal extremity of the protopodite, this segment may be looked upon as an abnormal endopodite, and may shed light on the solution of the problem as to whether it is the exopodite or the endopodite which disappears in the further development of the abdominal appendages in the male.

The third case occurred on the antenna. Normally, this appendage consists of a basal, two-jointed portion or protopodite, and a distal, two-jointed portion or endopodite, bearing a long, thin flagellum provided with a series of small spines, The antenna of the right side in this specimen had the basal segments perfectly normal, but attached to the distal segment of endopodite were three separate flagella. The central one, from its position, appeared to be the normal one, an abnormal flagella appearing on each side of it. The three flagella articulated separately with a special

segment developed at the distal extremity of the second segment of the endopodite. This segment does not occur in the normal condition, but the flagellum is attached by means of muscular tissue. It appears as though this tissue has become chitinised to give a firm attachment for the three flagella.

In the last case the abnormality also occurred in the flagellum of the antenna. From its point of attachment to its extremity it showed a peculiar spiral twist.

ANNUAL MEETING.

The Annual Meeting was held on Tuesday, September 30, 1919, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

Business :—

Election to Fellowship :—ANNIE PORTER, D.Sc., F.L.S., proposed by E. WARREN, E. M. DOIDGE, A. W. ROGERS, B. DE ST. J. V. D. RIET, A. L. HALL, and ANDREW YOUNG, was elected a Fellow.

An Ordinary Meeting was held on Wednesday, October 15, 1919, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Mr. H. C. G. OAKSHOTT, Boksburg, was nominated for membership by Dr. J. D. F. GILCHRIST, seconded by the Hon. General Secretary.

Dr. H. KRAMER and Dr. S. F. SILBERBAUER were elected Members.

The Council's recommendations to the Society as Members of Council for 1920 are as follows :—Seven Members of the existing Council, viz. : J. C. BEATTIE, L. CRAWFORD, J. D. F. GILCHRIST, W. A. JOLLY, C. W. MALLY, C. E. MOSS, A. OGG, with the following five additional Fellows :—H. B. FANTHAM, F. E. KANTHACK, L. PÉRINGUEY, B. DE ST. J. V. D. RIET, and ANDREW YOUNG.

The Council further recommended J. D. F. GILCHRIST as President, L. CRAWFORD as Hon. Treasurer, and W. A. JOLLY as Hon. General Secretary.

Demonstration :—

The President gave a Demonstration to the meeting of Ecdysis in the Horse-fish Agriopus.

The following communications were made :—

"Additional Note on the Resolvability of the Minors of a Compound Determinant," by Sir THOMAS MUIR.

"Colour and Chemical Constitution (Part IX.). An Empirical Law of Change of Colour," by JAMES MOIR.

The wave-lengths of the absorption-spectra of all the halogen derivatives, and many other derivatives of phenolphthalein and fluorescein, can be calculated from the formula

$$\frac{n}{n_o} = \frac{\lambda_o}{\lambda} = 1 - 0{\cdot}0115m - 0{\cdot}000037m\,\mathrm{N}$$

in which n=frequency, λ=wave-length, m=number of halogens, etc., and N=atomic number of halogen in question. All the groups investigated have very similar effects on the colour, a most remarkable fact.

"South African Alcyonacea," by J. STUART THOMSON.

ANNIVERSARY MEETING.

The Anniversary Meeting of the Society was held on Wednesday, March 17, 1920, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

In the absence of the President, Dr. L. CRAWFORD was in the Chair.

The following Fellows were admitted :—Dr. A. OGG, Dr. C. F. JURITZ, Mr. SIDNEY H. HAUGHTON, and Dr. ANNIE PORTER.

The Report of the Hon. General Secretary was submitted and adopted.

The Report of the Hon. Treasurer was submitted and adopted.

The following were elected Members of the Council for the year 1920 :—

Dr. J. C. BEATTIE.	Mr. C. W. MALLY.
Dr. L. CRAWFORD.	Dr. C. E. MOSS.
Dr. H. B. FANTHAM.	Dr. A. OGG.
Dr. J. D. F. GILCHRIST.	Dr. L. PÉRINGUEY.
Dr. W. A. JOLLY.	Dr. B. DE ST. J. VAN DER RIET.
Mr. F. E. KANTHACK.	Dr. A. YOUNG.

Dr. J. D. F. GILCHRIST, was elected President.

Dr. L. CRAWFORD, Hon. Treasurer.

Dr. W. A. JOLLY, Hon. General Secretary.

ORDINARY MEETING.

An Ordinary Meeting was held after the Anniversary Meeting.

Dr. L. CRAWFORD was in the Chair.

The Minutes of the last Ordinary Meeting were confirmed.

Mr. H. C. G. OAKSHOTT was elected a Member.

The following communications were made :—

"Magnetic Observations in Rhodesia," by the Rev. E. GOETZ, F.R.S.S.Af.

"Some Recent Researches on Cercariae found in certain South African Gastropods," by Dr. ANNIE PORTER, F.R.S.S.Af.

Brief descriptions with demonstrations of specimens were given of the larval forms of certain Trematodes found in *Physopsis africana* and *Limnaea natalensis*. The adult forms of these larvae in their respective vertebrate hosts were determined experimentally, using natural modes of infection. Adult *Schistosoma haematobium* and *S. mansoni* were obtained by exposing laboratory animals to water containing Bilharzia cercariae, and by giving them contaminated water as drink or by soaking food in contaminated water. A Distome fluke, *Fasciola gigantica*, was found in sheep, rabbits, and guinea-pigs after feeding them with green food containing encysted cercariae, probably *C. pigmentosa* of Cawston. Another cercaria developed into an Echinostome fluke in the Amphibian, *Xenopus laevis*. A fourth type of cercaria gave rise to a Monostome fluke in *Xenopus laevis*. Details regarding the experimental animals were given. These various larvae and adults have been found occurring naturally in South Africa.

The life-history of a liver fluke in sheep in South Africa, namely *Fasciola gigantica*, has thus been elucidated for the first time.

"On *Herpetomonas denticis*, a Parasitic Flagellate found in the Blood of the Silver-fish *Dentex argyrozona*," by Dr. H. B. FANTHAM, F.R.S.S.Af., and Dr. ANNIE PORTER, F.R.S.S.Af.

The organism is a new Protozoön found to occur naturally in the blood of fish, *Dentex argyrozona*, from St. James, near Cape Town. The parasite was also seen in small numbers in the spleen, liver, and kidneys. Flagellate forms measure from 5 to 24 microns long and 1·5 to 2·5 microns broad. Rounded, non-flagellate, leishmania-like forms were also observed. Multiplicative stages were found.

As far as is known, this is the first record of the natural occurrence of a Herpetomonas in the blood and internal organs of fishes. Three Dentex, out of twenty-five examined, were scantily parasitized. Herpetomonads were not found in the digestive tracts of the fish.

The significance of this piscine parasite is important, in view of the numerous experiments carried out by the authors and others on the successful infection of vertebrates with Herpetomonads and their relation to leishmania. The leishmaniases are really herpetomoniases of mammals, wherein herpetomonads—which are natural parasites of invertebrates, such as insects—have been introduced into vertebrates, such as mammals, with pathogenic effects.

Stained specimens of *Herpetomonas denticis* were exhibited.

"Contributions to our Knowledge of the Fresh-water Algae of Africa (No. III.: Fresh-water Algae of the Transkei)," by F. E. Fritsch and Miss E. Stephens.

The material described in this paper was collected from various parts of the Transkei, chiefly from the Kentani district, by Miss Pegler. In addition, a few samples from the Buffalo River at King William's Town have been examined. The species recorded from the Transkei alone (exclusive of Diatoms), number 141, belonging to 61 genera; these include 6 new species, a new sub-species, and 13 new varieties, apart from a number of new forms. Of these species, 42 are new records from South Africa. The collections show the Transkeian algal flora to be curiously deficient in Desmids and Protococcales, while the Blue-Green algae are relatively abundant—a feature often associated with conditions unfavourable to the growth of green forms. This may, perhaps, be correlated with the fact that Kentani, according to Miss Pegler, is said to be drying up and that surface water is less, streams smaller, and marshes disappearing.

"Colour and Chemical Constitution (Part X.). A General Numerical Solution of the Colour Constitution Problem," by James Moir.

Taking 593 as the wave-length of the vibration associated with the parent-substance of the dyes, the hydrocarbon $C_{19}H_{14}$ which is the anhydride of triphenylcarbinol, it is possible to calculate the colour of any derivative from the formula

$$\lambda = 593 \times f^{m} \times f^{n} \times f_{ii}^{p}, \text{ etc.}$$

in which f, f_i, f_{ii}, etc., are "colour-factors" which depend solely on what the chemical group is and where it is in the molecule, and m, n, p, etc., are the numbers of such groups present. The colour-factor for parahydroxyl is 0·966, that for paradimethylamino is 1·021, and so on. Twenty-five such factors are given in the paper. As an example, malachite-green is calculated to have $\lambda = 593 \times (1{\cdot}021)^2 = 619$, which agrees with observation. In certain cases the calculated colour agrees with the dye in acid, not neutral, solution.

"Second Note on the Determinant of the Sum of Two Circulant Matrices," by Sir Thomas Muir.

REPORT OF THE HON. GENERAL SECRETARY FOR 1919.

Seven Ordinary Meetings, the Annual Meeting, and the Anniversary Meeting were held during the year, and the following papers were read :—

1. "Some Notes of a Visit to Lake Fundusi in the Zoutpansberg District of the Transvaal," by T. G. TREVOR.

2. "Note on the so-called Branchial Arch in Lizards," by JOHN HEWITT.

3. "Note on Unimodular and Other Persymmetric Determinants," by Sir THOMAS MUIR.

4. "Note on Certain Determinant Identities arrived at by H. v. KOCH," by Sir THOMAS MUIR.

5. "Some Controversial Notes on the Diamond," by J. R. SUTTON.

6. "Note on Coloration produced in Clay by Injured Roots of *Pinus pinea*," by B. DE ST. J. V. D. RIET.

7. "Note on the Shells of *Schizoderma spengleri*," by J. D. F. GILCHRIST.

8. "An Extreme Case of Microcephaly," by Dr. DRU-DRURY.

9. "South African Microthyriaceae," by Miss ETHEL M. DOIDGE.

10. "Note on Carbolic Acid as a Fixative for Histological Preparations," by C. L. HERMAN.

11. "A Contribution to the Study of the Diamond Macle, with a Note on the Internal Structure of Diamond," by J. R. SUTTON.

12. "Bushman Engravings," by Dr. L. PÉRINGUEY.

13. "Comparative Study of Certain Cranial Sutures in the Primates," by Dr. R. W. SHUFELDT.

14. "Note on a Sum of Products which involves Symmetrically the *n*th Roots of 1," by Sir THOMAS MUIR.

15. "Note on Some Abnormalities in the Cape Crawfish (*Jasus lalandii*)," by C. v. BONDE.

16. "Additional Note on the Resolvability of the Minors of a Compound Determinant," by Sir THOMAS MUIR.

17. "Colour and Chemical Constitution (Part IX.). An Empirical Law of Change of Colour," by JAMES MOIR.

18. "South African Alcyonacea," by J. STUART THOMSON.

19. "New and Interesting South African Mosses," by H. N. DIXON.

The Society has awarded, on the recommendation of the General Committee for Grants-in-Aid of Research, the following grants :—£50 to Mr. C. W. V. D. MERWE for photographing the tracks of particles emitted by a Polonium Salt ; £50 to Rev. A. T. BRYANT towards the preparation of "An Early History of the Zulu and Neighbouring Tribes."

Vol. VII., Part 3, and Vol. VIII., Part 1, of the Society's Transactions have been issued during the year.

The number of Honorary Fellows is 3; Fellows, 47; Members, 170.

The Society regrets to have to record the deaths since the 1919 Anniversary Meeting of Sir MEIRING BECK, E. JACOT, C. D. LESLIE, Dr. W. F. PURCELL, Hon. W. P. SCHREINER, and Sir C. ABERCROMBIE SMITH.

Resignations have been received from Britstown Public Library and Mr. C. L. W. MANSERGH, I.S.O.

Four names were struck off the roll during the year.

With the exception of those which ceased during the War, and which have not yet been recommenced, the usual accessions to the Library have been duly received.

The question of the provision of additional shelving for the Library has become most urgent, and a decision should be come to without any further delay.

The Society's volumes of the Proceedings of the Royal Society, Amsterdam, are in the binder's hands.

5

TREASURER'S ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1919.

Revenue.	£ s. d.	£ s. d.
To Subscriptions received in 1919:		
for 1916, 1 Country Member at £1 ..	1 0 0	
for 1917, 1 Fellow at £2, 1 Town Member at £2, 3 Country Members at £1 ..	7 0 0	
for 1918, 4 Fellows at £2, 5 Town Members at £2, 14 Country Members at £1 (1 not counted in arrears, 1918 Accounts)	32 0 0	
for 1919, 46 Fellows at £2, balance 1 Fellow at £1, 45 Town Members at £2, 86 Country Members at £1..	269 0 0	
for 1920, part of 1 Town Member at 2s., 2 Country Members at £1	2 2 0	
		311 2 0
„ Entrance Fees (one for 1918)		14 0 0
„ Life Membership Subscription, Fellow ..		25 0 0
„ Sale of Publications to Government ..		100 0 0
„ Sale of Publications otherwise		15 4 9
„ Sale of Extra Reprints of Papers		4 2 6
„ Government Grant, 1919–20		300 0 0
„ Interest on Fixed Deposit, £800, at Standard Bank at 4½ per cent., less 4s. for Stamps on renewing Deposit		33 16 0
„ Interest on £400 Union of South Africa 5 per cent. Stock		20 0 0
„ Interest on Money in Savings Bank Department of Standard Bank		4 17 11
„ Research Grants: Refund of balance of a 1918 Grant		1 11 8
„ Publications: Contribution towards expenses of plates for a paper to be published in Transactions, Vol. VIII., Part 2 or 3		75 0 0
		£904 14 10

Expenditure.	£ s. d.	£ s. d.
By Publications		340 0 6
„ Research Grants:		
Payment of Grants	240 0 0	
Expenses in Advertising	4 17 0	
		244 17 0
„ International Scientific Catalogue of Papers:		
Compilation	25 0 0	
Dock Dues, etc., on case with 3 numbers	0 13 11	
		25 13 11
„ Clerical Assistance and Work in Library..		57 10 0
„ Local Printing and Stationery		41 9 0
„ Postages and Petties		15 0 0
„ Bank Charges for Commissions, Ledger Fees, etc.	3 7 6	
less Commissions paid by Members ..	1 18 9	
		1 8 9
„ Hire of Room for Meetings, Caretaker, 1919		6 6 0
„ Insurance of Library, Premium 1919–20 ..		0 10 6
„ Binding Periodicals in Library		8 2 6
„ Copies of Parts of Transactions bought for Library		1 4 7
„ Excess of Revenue over Expenditure ..		162 12 1
		£904 14 10

ASSETS AND LIABILITIES AS AT DECEMBER 31, 1919.

Assets.*	£	s.	d.	Liabilities.	£	s.	d.
Money at Standard Bank on Fixed Deposit at 4½ per cent.	800	0	0	Subscriptions, whole or part, received for 1920	2	2	0
Money in Savings Bank Department of Standard Bank ..	257	15	3	Research Grant unpaid in part: Professor J. T. Morrison ..	80	0	0
Union of South Africa 5 per cent. Stock (1921–1936) ..	400	0	0	Publications and Transactions, estimated	120	0	0
Balance at Standard Bank, as per Pass Book	75	16	8	Contributions towards Plates in Number of Transactions, Vol. VIII., Part 2 or 3	75	0	0
Arrears of Subscriptions, as in Statement for 1918, £62, less £39 paid in year and £3 struck off as irrecoverable ..	20	0	0	Binding Periodicals in Library	10	0	0
Arrears of Subscriptions for 1919	37	18	0	Earmarked for Expense of Publishing, as a part of the Transactions, a Reproduction of a Bushman Painting (Council Minutes, May 12, 1915), a sum not exceeding	350	0	0
Amount due for Extra Reprints of Papers	8	2	0	Balance from 1912 Conversazione carried forward towards the expenses of future conversazione in Cape Town ..	7	4	0
				Capital at December 31, 1919, being excess of assets over liabilities	955	5	11
	£1599	11	11		£1599	11	11

* Exclusive of value of Library and Publications of the Society held in stock.

Entrance Fees and Life Subscriptions Fund, 1918 and 1919.

	£	s.	d.		£	s.	d.
Amount of Fund at January 1, 1918	167	0	0	Amount of Fund at December 31, 1919	246	0	0
Received in 1918: Entrance Fees, £15, Life Subscription (Fellow), £25	40	0	0				
Received in 1919: Entrance Fees, £14, Life Subscription (Fellow), £25	39	0	0				
	£246	0	0		£246	0	0

We hereby certify that we have examined the above balance and revenue accounts with the books, vouchers, and Banker's pass book relating thereto, and that, in our opinion, they correctly set forth a true and correct statement of the affairs of the Society.

S. S. HOUGH.
SIDNEY H. HAUGHTON.

An Ordinary Meeting was held on Wednesday, April 21, 1920, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

The President announced his nomination of Dr. A. Ogg and Dr. H. B. Fantham as Vice-Presidents for the year 1920.

The following communications were made :—

"Note on the Whales frequenting South African Waters," by L. Péringuey.

The author describes the various whales which are known to frequent the coasts of South Africa. The number of these is still under discussion. The fact is now well established that certain Northern whales are specifically identical with the Southern whales and are the kinds of whales found on our coast. That they are migrants, perhaps with the exception of *Balaenoptera Brydei* is a well-established fact, but what is probably less known is that the animals go to warmer equatorial waters to breed or calve. If they are intercepted on their way there from the Antarctic or on their return the multiplication of the species will be greatly hindered, to say the least. People interested in the whaling industry admit that some measure of protection is necessary.

"Overgrowths on Diamond," by J. R. Sutton.

In this paper the author discusses in detail overgrowths of calcite, bort of various kinds, graphite, and diamond, on diamond. Experiments were made with the object of determining why certain diamonds from yellow ground are not separated from the concentrates on the grease tables ; the conclusion being reached that carbonate of lime readily forms a coating on a diamond surface, causing the diamond to behave like a common mineral in the pulsator gravel. A clear diamond is readily wetted by a solution of carbonate of soda, but not by pure water. Overgrowths of graphite and of black bort are common and define per saltum stages of crystallisation. Thirteen specimens of "hailstone" structure are described. Laminated diamonds appear to be examples of overgrowth of diamond on diamond with interposing planes of colouring matter.

"Some Statistics of Thunder and Lightning at Kimberley," by J. R. Sutton.

The author gives tables of the results of eye and ear observations of Thunder and Lightning made at Kimberley during the twenty-three years 1897 to 1919, and classifies the storms according to the classification given by Ley. A phenomenon of interest is the "smell" of a thunderstorm.

The author only observed this once strongly in Kimberley. European meteorological literature of the seventeenth and eighteenth centuries has many allusions to the "sulphureous smell" of lightning.

"Notes on Some South African Entomophthoraceae," by S. H. SKAIFE.

The material used by the author was collected at Cedara, Natal, in 1919 and 1920. The great majority of the family are parasitic on insects. The author describes and figures South African species of Entomophthoraceae and his experiments of cultivating them from dead and dying flies and grasshoppers and of infecting insects from the cultures.

In the course of the discussion on Dr. PÉRINGUEY'S communication, it was moved by Mr. J. BURTT-DAVY and seconded by Dr. C. L. HERMAN that the Council of the Society be asked to approach the Authorities and draw their attention to the danger that the whales in South African waters will be exterminated unless some measure of protection is applied.

An Ordinary Meeting was held on Wednesday, May 19, 1920, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. A. YOUNG was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Professor EDGAR NEWBERY, D.Sc., F.I.C., F.I.S., and Professor J. W. C. GUNN, M.B., Ch.B., were nominated for membership.

Demonstration :—

Mr. S. H. HAUGHTON, B.A., gave a note on the occurrence of a species of Baboon in Limestone deposits near Taungs, and demonstrated the fossils which have been discovered.

The limestone deposits in question have yielded partial skulls of seven or eight individuals of a small species of Baboon, which is much smaller than, and in other ways different from, the species now inhabiting South Africa. The species is distinct in that, although all the specimens have obtained the second set of molars and are thus adult, although possibly not mature, there is a complete absence of the brow-ridges characteristic of *Papio porcarius* and its allies. The name *Papio antiquus* sp. nov. is proposed for the form.

At present it seems impossible to correlate our inland Tertiary and Recent deposits with those of the Northern Hemisphere ; but from the nature of the occurrence of the forms it is probable that the form may extend back in point of time to a level contemporaneous with the early or possibly pre-Pleistocene of Europe.

The following communications were made :—

"Colour and Chemical Constitution (Part XI.). A Systematic Study of the Brominated Phenolphthaleins regarding the Relation between Position and Colour," by JAMES MOIR.

The spectra of 23 bromine-derivatives of phenolphthalein are described, these being selected from the 658 possible isomers so as to give clear evidence of the value of each of the twelve possible positions for bromine as regards change of colour. These values are tabulated, whereby any of the uninvestigated 636 isomers should be calculable. Phenolphthalein differs from benzaurine in not having a negative paraposition ; hence the author concludes that the current chemical formula for the former is incorrect, and suggests a new formulation.

"A Note on the Relationship between Cloud and Sunshine," by J. R. SUTTON.

In this paper the author undertakes a brief discussion of the observations of sunshine and cloud made during the twenty years 1900 to 1919 at Kimberley. In a general way much sunshine postulates little cloud ; but the relation is not intimate, and a sunshine recorder cannot be regarded as an automatic device for determining the cloudiness of the sky. August gets the most sunshine, February the most cloud.

"The Haustoria of the Genera Meliola and Irene," by Miss ETHEL M. DOIDGE.

The fungi belonging to the genus Meliola are true parasites, sending haustoria into the cells of the host. The most common type is that which has a fine filament penetrating the cuticle and a small globular, thin-walled, uninucleate vesicle in the epidermal cell. Certain species penetrate through the epidermis, through sclerenchyma cells, if these are present, into the first chlorophyll-containing cells of the mesophyll. The haustoria cause a considerable disorganisation of the cells into which they penetrate, and the mycelium completely blocks many of the stomata.

The following are candidates for Fellowship ;—KEPPEL HARCOURT BARNARD, M.A., proposed by L. PÉRINGUEY, S. H. HAUGHTON, A. W. ROGERS, ANDREW YOUNG, and C. W. MALLY ; J. W. BEWS, M.A., D.Sc., proposed by R. MARLOTH, I. B. POLE EVANS, E. M. DOIDGE, and S. SCHÖNLAND ; Mrs. FRANK BOLUS, B.A., proposed by R. MARLOTH, I. B. POLE EVANS, S. SCHÖNLAND, and E. M. DOIDGE ; JOHN PATRICK DALTON, M.A., D.Sc., proposed by J. T. MORRISON, B. DE ST. J. V. D. RIET, ALEXANDER BROWN, S. SCHÖNLAND, and CHAS. F. JURITZ ; THOMAS JONES MACKIE, M.B., Ch.B., D.P.H., proposed by A. JASPER ANDERSON, A. MARIUS WILSON, GEO. W. ROBERTSON, and S. S. HOUGH ; EDWIN PERCY PHILLIPS, M.A., D.Sc., F.L.S., proposed by I. B. POLE EVANS, E. M. DOIDGE, S. SCHÖNLAND, and R. MARLOTH.

An Ordinary Meeting was held on Wednesday, June 16, 1920, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The Vice-President, Dr. A. OGG, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Mr. SYDNEY GARSIDE, M.Sc., was nominated for membership by Dr. L. PÉRINGUEY, seconded by Mr. S. H. HAUGHTON ; Mr. J. H. POWER was nominated by Dr. L. PÉRINGUEY, seconded by Miss WILMAN.

Professor EDGAR NEWBERY, D.Sc., F.I.C., F.I.S., and Professor J. W. C. GUNN, M.A., M.B., Ch.B., were elected members of the Society.

The Hon. Secretary was instructed to write to Sir CARRUTHERS BEATTIE, a Fellow and former Hon. General Secretary of the Society, congratulating him in the name of the Society on the honour which has been conferred upon him.

The following communications were made :—

1. " Note on a Recent Discovery of Stone Implements of Palaeolithic Type, throwing Light on the Method of Manufacture in South Africa," by L. PÉRINGUEY.

The author described a collection of palaeolithic stone implements from the Montagu Caves and showed that the completed implement is flattened, rounded at one end and tapering to a point at the other, and being chipped to a sharp edge all the way round. From this demonstration it is now possible to pronounce that many of the implements so far known, which are blunt at one part or another, are unfinished or damaged specimens. Further, it is shown that a large block was chipped down in order to form a relatively small, delicately worked implement, and the very large chipped stones that have sometimes been found are seen to be initial stages in the manufacture.

2. " The Reflex Times in Xenopus Laevis," by W. A. JOLLY.

The author described his method of measuring exactly the reflex times, in the reflexes from the limbs of the S.A. clawed frog or toad, and gave a note of the times ascertained in the decerebrate animal.

3. " Notes on the Platana of the Cape Peninsula," by C. LAWRENCE HERMAN.

The marked difference in the shoulder girdle of the Platana of the Cape Peninsula, from that described and figured by Boulenger as appertaining to *Xenopus Laevis*, was pointed out.

The precoracoids form a large, lozenge-shaped, sternal plate, and the epicoracoids overlap.

The shoulder girdle resembles that of *X. muelleri*, but the clavicles are broader mesially.

There is a small metatarsal spur, and the sub-ocular tentacle is rudimentary.

The importance of the shoulder girdle as a basis for systematic classification was referred to, and the probability of this Platana being a primitive form was suggested.

The formation of the external nasals was described, and attention directed to the horny epidermal fold on the superior half of the nasals which gives it rigidity. The synchronous contractions of the nasals and the movement of the premaxilla and maxilla were described and their nature discussed.

It was suggested that this occurs in all the Xenopus, and the wish was expressed that this remarkable phenomenon now described for the first time should be looked for in the case of water-frogs generally.

4. "A Possible Lunar Influence upon the Velocity of the Wind at Kimberley (Second Paper)," by J. R. Sutton.

In this paper the author continues the investigation described in a previous paper under the same title. A Table and a Diagram are given showing the deviations of wind-speed at the times of perigee from the monthly means, arranged in hours of the lunar day. The ranges of velocity deduced are somewhat greater than those previously found for the average of all lunar distances. The noon and midnight perigee curves are remarkable, and suggest that the wind-speed deviations attributable to the moon are largely due to the superimposition of the lunar air tide upon the diurnal variations of wind velocity. Thus, no two different places could be expected to have quite the same velocity deviation curves.

An Ordinary Meeting was held on Wednesday, July 21, 1920, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The Vice-President, Dr. A. Ogg, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Professor C. F. M. Saint, C.B.E., M.D., M.S., F.R.C.S., was nominated for membership.

Mr. Sydney Garside, M.Sc., and Mr. J. H. Power were elected Members.

It was announced that the Council recommend to the Society the following five Candidates for election to Fellowship :—Keppel Harcourt Barnard, M.A., J. W. Bews, M.A., D.Sc., Mrs. Frank Bolus, B.A., John Patrick Dalton, M.A., B.Sc., D.Sc., and Thomas Jones Mackie, M.B., Ch.B., D.P.H.

The following communications were made :—

"The Genus Tulostoma, Persoon, in South Africa," by Paul A. van der Bijl.

This is a widely distributed genus, and in South Africa two species are thus far known, viz. :—*Tulostoma cyclophorum* and *Tulostoma Lesliei*, a new species, which the author describes in this paper.

"On a Fungus *Ovulariopsis Papayae* n. sp., which causes Powdery Mildew on the Leaves of the Pawpaw Plant (*Carica Papaya* Linn.)," by Paul A. van der Bijl.

The author describes a fungus found in Natal on the under surface of the pawpaw leaves as a new species, for which the name *Ovulariopsis Papayae* is suggested.

"South African Xylarias occurring around Durban, Natal," by Paul van der Bijl.

Four species of Xylarias have thus far been collected by the writer around Durban, and of these, three have not been previously recorded from South Africa. The author describes them in this paper.

"Note on the Spinal Reactions of the Platana," by W. A. Jolly.

The author gives a note of reflex times observed in the spinal preparation of the Platana of the Cape Peninsula (*Xenopus laevis* or an allied species).

"A Possible Lunar Influence upon the Velocity of the Wind at Kimberley (Third Paper)," by J. R. Sutton.

This paper deals with the variations in the speed of the wind when the moon is farthest from the earth. The discussion follows the same lines as the previous one, which dealt with the speed variations at perigee. The results obtained go to confirm the earlier ones. The diagram curves show generally the same turning-points as the perigee curves, but later in time, and the moonrise minimum is not so pronounced. The apogee curves average lower on the scale than the perigee ones. While the velocity of the wind tends to rise at perigee when the moon is above the horizon, it tends to fall at apogee. The porigee curves end the day at a higher level than what they started at, but the apogee curves run down.

An Ordinary Meeting was held on Wednesday, August 18, 1920, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. A. Ogg, Vice-President, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Professor C. F. M. Saint, C.B.E., M.D., M.S., F.R.C.S., was elected a Member.

Mr. V. A. Putterill, M.A., Government Mycologist, Cape, was nominated for Membership.

The following communications were made :—

"Note on Lysurus Woodii (MacOwan) Lloyd," by Paul A. van der Bijl.

The fungus described was found in a rhubarb trench in Natal. It is entirely distinct from the genus Anthurus.

"A Prehistoric Rock-sculpture from the North-Eastern Transvaal," by C. Pijper.

Circular and semi-circular stone markings are described, with photographs, from the Lijdenburg District, not far from stones engraved with cup-and-ring markings, which the author has previously described.

"Colour and Chemical Constitution. Part XII.: The Calculation of Colour from the Tautomeric Theory," by James Moir.

Assuming that the tautomerism C—C—OH→CH—C—O has the value λ 94, the tautomerism C—C—NH_2→CH—C—NH the value λ 98, and the tautomerism C—C—CH_2→CH—C—CH the value λ 103, it is shown that the molecule of a coloured substance can generally be dissected into tautomeric pieces, loaded with non-tautomeric portions which have very little effect on the colour (λ 7 to 20 only). On adding up the values of all the pieces the result agrees closely with the λ observed in the coloured substance. Yellow and orange substances have 3 or 4 tautomerisms, pink and purple substances have 4 or 5, blue and green substances 5 or 6.

The Annual Meeting was held on Wednesday, September 29, 1920, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

Business :—

Election to Fellowship :—The following candidates were elected Fellows : Keppel Harcourt Barnard, M.A.; J. W. Bews, M.A., D.Sc.; Mrs. Frank Bolus, B.A.; John Patrick Dalton, M.A., B.Sc., D.Sc.; and Thomas Jones Mackie, M.B., Ch.B., D.P.H.

An Ordinary Meeting was held after the Annual Meeting.

The President was in the Chair.

Business :—

The Minutes of the last Ordinary Meeting were confirmed.

Mr. V. A. Putterill, M.A., and Mr. F. C. Carveth were elected Members.

Mr. R. Bigalke and Mr. J. C. Morom were nominated for Membership.

The following communications were made :—

"A possible Lunar Influence upon the Velocity of the Wind at Kimberley (Fourth Paper)," by J. R. Sutton.

The object of this part of the discussion is to determine whether there are any points of agreement between the air tides and the lunar wind period sufficiently definite to form the nucleus of a theory which could be used to explain the comparatively great air speeds found in previous papers and which are attributable to the moon. For this purpose the air tides at perigee and at apogee have been determined (by Sabine's method) for the ten years 1897 to 1906 and compared with the wind movements. A diagram is given showing how the air pressures and wind movements compare one with the other. Both agree in the main ; though with certain important exceptions confirming previous conclusions that the lunar influence upon the velocity of the wind cannot be exerted in a very simple way through the medium of the air tides. A comparison is also made between the mean daily pressures and velocities during the course of the tropical month.

"On the Integrated Velocity Equations of Chemical Reactions," by J. P. Dalton.

The object of the note is to show how the integrals of many velocity equations which occur in practice may be written down in terms of a certain function of the relative initial concentrations of the reactants and of its derivatives. The function in question is :

$$\psi(x) = \frac{1}{x-1} \log \frac{1 - \frac{\lambda}{x}}{1 - \lambda}.$$

"Medical Folklore of the Abantu in the Lijdenburg District," by Cornelis Pijper.

The paper contains contributions to our knowledge of the methods of treatment used by the witch-doctors.

"The Action of Urginea Burkei," by J. W. C. Gunn.

Experiments were performed on frogs, rabbits, cats, rats, and guinea-pigs with extracts of Urginea Burkei (Baker) commonly known as the Transvaal Slang-kop. It has an action on the alimentary system, producing vomiting and diarrhœa, and on the nervous system resulting in loss of power in the limbs, diminution of reflexes, and final paralysis. Its main action is on the circulatory system. The effect on the frog's heart and on the isolated mammalian heart is to cause slowing, increase of systole, and diminution of relaxation, with ultimate arrest in complete systole. It first slows the mammalian heart *in situ*, but later it becomes quick and irregular, and usually fibrillates before being arrested in diastole. Intravenous injection is followed by a marked rise of blood-pressure, which is due partly to

the cardiac action and partly to constriction of the blood-vessels mainly of the splanchnic area. The action is the same as that of the digitalis group.

"A Revision of the South African Agamas allied to Agama hispida, A. atra, and A. anchietae," by G. A. BOULENGER and J. H. POWER.

The paper contains a revision of the group of South African reptiles which has stood most in need of revision. The account in the British Museum Catalogue of Lizards has long ceased to fulfil its purpose, and the attempt is now made, with the help of a very large amount of material, to arrive at conclusions which will stand the test of time.

"A Species of Microdon (Diptera) from Natal," by S. H. SKAIFE.

The paper gives a description of the larva, puparium, and adult female of Microdon illucens, Bezzi, the growth being under the author's observation.

"Note on Living Fish brought by H.M.S. *Challenger*," by J. D. F. GILCHRIST.

An Ordinary Meeting was held on Wednesday, October 20, 1920, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

Business :—

The Minutes of the previous meeting were confirmed.

Mr. R. BIGALKE and Mr. J. C. MOROM were elected to Membership.

The following were nominated for Membership : Mr. R. D. AITKEN, B.Sc., proposed by Professor D. THODAY, seconded by Professor J. W. BEWS ; Dr. G. W. BAMFYLDE DANIELL, M.R.C.S., L.R.C.P., proposed by Dr. A. MARIUS WILSON, seconded by the Hon. General Secretary.

The Hon. General Secretary announced the Council's recommendation for Officers and Council for 1921, as follows :—

President : Dr. J. D. F. GILCHRIST ; Hon. Treasurer : Dr. L. CRAWFORD ; Hon. General Secretary : Dr. W. A. JOLLY ; Dr. H. B. FANTHAM, Mr. J. HEWITT, Mr. S. S. HOUGH, Dr. C. F. JURITZ, Mr. C. P. LOUNSBURY, Dr. L. PÉRINGUEY, Dr. B. DE ST. J. VAN DER RIET, DR. A. YOUNG, Dr. R. B. YOUNG.

The following communications were made :—

"Observations on Living Fish brought by H.M.S. *Challenger* from Tropical East Africa to Cape Waters," by J. D. F. GILCHRIST.

In January 1919, H.M.S. *Challenger* brought six species of fish from Dar-es-Salaam, Port Amelia, Mnazi Bay, and Zanzibar.

On arrival at Simons Bay they were transferred to the tanks of the

Government Marine Station. They throve very well till April 25, when they all died within a few days of each other. At this date there was a sudden fall in the temperature of the water. The significance of this occurrence in connection with the distribution of fish in South Africa is discussed. Some observations were made on the sleeping habits of *Balistes aculeatus*.

"Detection of Induced Beta-ray Emission from Substances exposed to Röntgen Rays by a Photographic Method (Preliminary Paper)," by Lewis Simons.

A narrow beam of Röntgen rays from a Coolidge tube impinging on a film of red-lead laid down on paraffin wax gives a marked effect on a photographic plate placed opposite up to a distance, in air, of about 2 cm. from the red-lead. If a photographic plate replaces the red-lead a similar though less intense effect is shown on the opposite plate. This excited radiation was almost stopped by the thinnest mica and paraffin wax. Of beta rays and secondary X-rays from the same mass of substance in the form of a thin layer, the former seems to be by far the more important in producing a photographic impression.

"A Contribution to the Study of the Rainfall Map of South Africa," by J. R. Sutton.

This paper gives particulars of the monthly and annual rainfall for 567 stations in South and East Africa. The results are shown graphically in thirteen maps. Most South African rain falls in thunderstorms, and its distribution is not greatly affected by topographical influences. The isohyets form a system which moves to and fro across the equator, following the sun with a lag of a month or more. Corresponding to the general movements of the main isohyetal system are the winter rains of the south-west, which advance inland as the summer rains retreat, and *vice versa*. Various details of rainfall are mentioned, and some great hailstorms are described. The paper concludes with a short bibliography of special studies of South African rainfall.

"Some Notes on Ancient Ideas concerning the Diamond," by J. R. Sutton.

These notes are in the nature of a running commentary on a recent paper by B. Laufer. Various prosaic "motives" for some of the legends and stories about the diamond current in ancient times are suggested. For example, pigeons, poultry, and ostriches are known to swallow such things as diamonds and other bright minerals, and this fact may explain the origin of the legend of the diamond valley as it appears in Sinbad the Sailor and elsewhere. Again, some ancient lapidary may have anticipated Crookes by putting a diamond in a vice and so found that the iron might crush, but still suffer somewhat itself from the stone, thus starting the exaggeration

of Pliny and others about the indestructibility of the diamond by iron. It is argued that Pliny when he spoke of adamas as a name given to a crystal of gold was probably referring to the outside appearance of the crystallisation.

"Experimental Infestation of Fresh-Water Snails," by F. G. Cawston.

The author describes experiments in which he succeeded in causing infestation of Limnaea natalensis by Fasciola from a sheep's liver, also infestation of Physopsis africana by water containing the miracidia of Schistosoma hæmatobium; here the mature cercariae were found six weeks later. Other experiments are also described.

"The Water Relations of the Pine (P. pinaster) and Silver Tree (Leucadendron argenteum)," by R. D. Aitken (communicated by Professor D. Thoday).

The conductivity of the wood for water, rate of transpiration, total area of leaf-surface and sectional area of wood have been determined for similar twigs of pine and silver tree. The measurements of conductivity of pine wood agree with those of Farmer for other species. Silver tree twigs have a high conductivity for an evergreen tree, more than double that of pine. Cut twigs of Pine transpire, on the other hand, far more vigorously both twig for twig and per unit area of leaf surface. Under the experimental conditions, therefore, the pine leaves exerted a much greater suction force, calculated in one instance to be about four times that exerted by the silver tree leaves. The latter are less able to resist drying than pine leaves, in which the rate of transpiration very rapidly diminishes when the twig is not supplied with water to a much lower level than in a silver tree twig under identical conditions.

"The Action of Eucomis Undulata" (Preliminary Communication), by J. W. C. Gunn.

Eucomis undulata contains a large amount of a sapoglucoside, soluble in water and 90 per cent. spirit. It is a powerful hæmolytic agent. Absorption of the extract from the stomach and intestines and from the subcutaneous tissues is very slow; but intravenous injections are actively poisonous and produce symptoms like other saponin bodies.

"A Study of the Bacillus Coli Group with Special Reference to the Serological Characters of these Organisms," by T. J. Mackie.

The paper is a detailed record of investigations on the B. coli group with reference to their (1) biological classification; (2) serological characters; (3) mutations.

The more important literature bearing on the subject is reviewed, and it is shown that while different systems of classification have been adopted which have served a practical purpose as regards the recognition of "typical" varieties, it can hardly be claimed that these organisms have yet

been completely classified, nor that the significance of different characters has been accurately assessed.

The biological characters of 246 strains of gram-negative, ærobic, non-sporing, non-liquefying glucose fermenting bacilli (not including specific pathogens of this class) were studied. Different types were recognised by a comprehensive set of criteria.

It was possible to classify these types into certain main sub-groups: (1) in view of the fact that certain types possessed well-marked common characters; (2) as a result of the study of the group reaction of complement deviating anti-bodies to some of the commoner varieties.

Four main sub-groups could be recognised—

A.—gas-producing, indol-forming, non-inosite-fermenting.

B.— „ non-indol-forming, „

C.— „ inosite-fermenting.

(The C types produced large, thick, opaque, slimy colonies, and fermented lactose, sacchariose, and adonite.)

D.—non-gas-producing (anærogenes types).

Sub-group A embraced the commoner varieties—the "typical B. coli."

The different types were designated numerically under the particular sub-group in order of their frequency in the series investigated.

The serological characters studied were (1) the agglutination; (2) complement deviation reactions of immune sera to certain of the commoner varieties—these observations proved of great interest from the purely immunological standpoint, and also threw some further light on the biological relationships of the various types of coliform bacilli.

In sub-group A the agglutinin showed a highly restricted specificity, *i.e.* for the individual strain: by agglutination and agglutinin absorption tests no difference could be established between different cultural types; in this sub-group a high degree of individuality is attained by each strain, and differences of cultural characters within certain limits are of little significance. The complement deviating anti-bodies showed a marked relative specificity for the individual strain (but not for the cultural type), and also a group reaction strictly limited to the types of sub-group A.

The serological characters of types belonging to sub-group B were also studied.

The comparative resistance of various types to brilliant green was correlated with the grouping determined by cultural and serological tests.

Mutations among these organisms were also investigated, and afforded some explanation of the great diversity of cultural types and the high degree of specialisation in the serological characters of individual strains.

"Note on Over-Voltages," by E. Newbery.

Recent investigations on over-voltage appear to point to the conclusion

that this property is closely connected with the valency electrons of the atom. It has been shown (*Journ. Chem. Soc.*, 1916, 109, 1111) that the hydrogen over-voltage of a metal is determined by the group of the periodic table in which it occurs, and further, that if the metal shows different valencies corresponding to other periodic groups, it will also, under suitable conditions, show over-voltages corresponding to the same groups. Again it was pointed out in the same communication, that if the single potential of the hydroxyl electrode be taken as standard in place of that of the oxygen electrode, then oxygen, or rather hydroxyl over-voltages show values almost coinciding with hydrogen over-voltages of the same metal. The data available at the time were considered insufficient for any far-reaching conclusions to be drawn, but recent work on chlorine over-voltages has shown that they also coincide with hydrogen and hydroxyl over-voltages. Over-voltage appears, therefore, to be a function independent both of the gas liberated and of the metal in question, and completely determined by valency alone. Whether the valency of the gas is involved or not is still an open question, since all the gaseous ions used were monovalent.

It seems probable, therefore, that the over-voltage compounds carry excess electrons, and that the addition of each electron produces a definite increment in the single potential, which increment is dependent only upon the number of free valency electrons present in the atom of the electrode or ion of the over-voltage compound.

Anniversary Meeting.

The Anniversary Meeting of the Society was held on Wednesday, March 16, 1921, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

The Report of the Hon. General Secretary was submitted and adopted.

The Report of the Hon. Treasurer was submitted and adopted.

The following were elected Members of the Council for the year 1921: Dr. L. Crawford, Dr. H. B. Fantham, Dr. J. D. F. Gilchrist, Mr. J. Hewitt, Mr. S. S. Hough, Dr. W. A. Jolly, Dr. C. F. Juritz, Mr. C. P. Lounsbury, Dr. L. Péringuey, Dr. B. de St. J. v. d. Riet, Dr. A. Young, and Dr. R. B. Young.

Dr. J. D. F. Gilchrist was elected President; Dr. L. Crawford, Hon. Treasurer; and Dr. W. A. Jolly, Hon. General Secretary.

An Ordinary Meeting was held after the Anniversary Meeting.

The President was in the Chair.

The Minutes of the last Ordinary Meeting were confirmed.

Mr. R. D. Aitken, B.Sc., and Dr. G. W. Bamfylde Daniell were elected Members.

Miss M. R. Michell, B.A., proposed by Professor D. Thoday, seconded by Miss E. L. Stephens, was nominated for Membership.

Professor T. J. Mackie was admitted to Fellowship.

Demonstration :—

A demonstration of some abnormalities in the human eye, illustrated by a large number of specimens, was given by Dr. D. J. Wood.

The following communications were made :—

(1) " The Permanganate Absorption Spectrum : A Claim for Priority. (2) A Formula for Calculating the Uranium Spectrum," by James Moir.

A claim for priority over E. Adinolfi (1920) is made in regard to a formula for calculating the permanganate spectrum, which this Society published in 1918. A similar formula : $^1/\lambda = 2113 + 66N$, expresses the uranium ion spectrum, and the spectrum of the solid salts is also calculable by applying the sixth-root-formula published in 1918.

" Colour and Chemical Constitution. Part XIII. : The Calculation of the Colour of the Monocyclic Dyes," by James Moir.

A dye is " monocyclic " if, however many rings it contains, only one of its rings carries an ionisable group like hydroxyl. Paraoxybenzyl alcohol of $\lambda 290$ is the parent substance, and the colours of the dyes are calculated as in Part X. by multiplying 290 by factors, one for each of the groups in the formula of the dye. Factors for phenyl, amino, *N*-methyl, and *o*-carboxyl are given in the paper, these four enabling all the colours to be calculated correctly : colours of unknown substances are also predicted.

" Colour and Chemical Constitution. Part XIV. : The Calculation of the Colour of the Dicyclic Dyes," by James Moir.

It has been found that the effect of introducing a second linkage into a dye containing *two* ionisable rings linked by CH_2, CHOH, CO, NH, NOH, O or S (a " dicyclic " dye), is the same whichever of these seven linkages is first present. Each of these linkages has a fixed numerical factor, viz., 0·65, 0·39, 0·23, 0·78, 0·47, 0·89, and 0·91 respectively, and the colour can be calculated by multiplying a constant (1380 for di-phenolic dyes, 1400 for di-aniline dyes, and 1548 for bis-dimethylaniline dyes) by the factor or factors of the one or two linkages in the dye. Thus resorufine, which contains 2 phenol rings linked by NOH and O, has the calculated wave-length $1380 \times 0{\cdot}47 \times 0{\cdot}89 = 577$, which agrees with observation. Thirty-four examples of well-known dyes such as fluorescein, methylene-blue, and

safranine are thus calculated correctly; for the more complicated cases the factors given in Part X. are used in addition to the above seven linkage-factors.

"The Crystalline Structure of Antimony and Bismuth," by A. Ogg.

It was shown that the unit rhomb of the antimony crystal contains eight atoms, but that a distorted diamond structure would not explain the X-ray spectra obtained by reflection from the faces of the crystal. The structure proposed by James and Tunstall (*Phil. Mag.*, Aug. 1920), with slight modifications, was found to satisfy the spectra. The structure consists of two interpenetrating face-centred lattices, the relative positions of the two lattices being determined by the spectra from the (III) face. The relative intensities of these spectra differed from that given by James and Tunstall. The relative positions of the atomic planes and the shortest distance atomic centres have been worked out.

"On Braula Caeca, Nitzsch, a Dipterous Parasite of the Honey Bee," by S. H. Skaife.

Braula caeca is an aberrant dipteron, that is, an external parasite of the honey bee. Hitherto this insect has been thought to be pupiparous, but recent studies carried out at Cedara, Natal, have shown that the female oviposits on the brood combs in the hives, the eggs hatch out into normal dipterous larvae, which make their way into the cells occupied by the bee larvae, feed on the food supplied to the bee larvae without harming their hosts, pupate inside the cells, and finally emerge as adults and creep on to the bodies of their hosts.

"Notes on the Development of the Ovule, Embryo Sac, and Embryo of Hydnora Africana (Thunb.)," by R. H. Dastur.

The author shows that the ovule of Hydnora is orthotropous with a single integument; the megaspore mother cell is hypodermal and becomes the embryo sac; the proembryo consists of a row of about 15 cells, and the embryo is produced from the middle region of the proembryo.

"Note on a Fire-Flint of Strandlooper Origin," by John Hewitt.

The author describes an implement found in a cave near Plettenberg Bay, consisting of a small piece of chalcedony roughly trimmed, presenting a concave cutting edge: this is mounted in a large lump of resin; a horn handle with slender and tapering distal end fitting into a comparatively short socket in the resin. The author puts forward the suggestion that it has been used by the Bushmen as a fire-flint.

"A Note on the Use of the South African Clawed Toad in the Biological Assays of the Digitalis Series," by J. W. C. Gunn.

The South African Clawed Toad reacts to digitalis bodies quantitatively like the frog, not the toad. It may be used like Rana in the biological essays of digitalis tinctures.

REPORT OF THE HON. GENERAL SECRETARY FOR 1920.

Eight Ordinary Meetings, the Annual Meeting, and the Anniversary Meeting were held during the year, and the following papers were read :—

1. " Magnetic Observations in Rhodesia," by E. GOETZ.

2. " Some Recent Researches on Cercariae found in certain South African Gastropods," by Dr. ANNIE PORTER.

3. " On Herpetomonas denticis, a Parasitic Flagellate found in the Blood of the Silver-fish Dentex argyrozona," by H. B. FANTHAM and Dr. ANNIE PORTER.

4. " Contributions to our knowledge of the Fresh-water Algae of Africa. No. III.: Fresh-water Algae of the Transkei," by F. E. FRITSCH and Miss E. STEPHENS.

5. " Colour and Chemical Constitution. Part X.: A General numerical Solution of the Colour Constitution Problem," by JAMES MOIR.

6. " Second Note on the Determinant of the Sum of two Circulant Matrices," by Sir THOMAS MUIR.

7. " Note on the Whales Frequenting South African Waters," by L. PÉRINGUEY.

8. " Overgrowths on Diamond," by J. R. SUTTON.

9. " Some Statistics of Thunder and Lightning at Kimberley," by J. R. SUTTON.

10. " Notes on some South African Entomophthoraceae," by S. H. SKAIFE.

11. " Colour and Chemical Constitution. Part XI.: A Systematic Study of the Brominated Phenolphthaleins regarding the Relation between Position and Colour," by JAMES MOIR.

12. " A Note on the Relationship between Cloud and Sunshine," by J. R. SUTTON.

13. " The Haustoria of the Genera Meliola and Irene," by Miss ETHEL M. DOIDGE.

14. " Note on a Recent Discovery of Stone Implements of Palaeolithic Type, Throwing Light on the Method of Manufacture in South Africa," by L. PÉRINGUEY.

15. " Reflex Times in Xenopus Laevis," by W. A. JOLLY.

16. " Notes on the Platana of the Cape Peninsula," by C. LAWRENCE HERMAN.

17. " A possible Lunar Influence upon the Velocity of the Wind at Kimberley. (Second Paper)," by J. R. SUTTON.

18. " The Genus Tulostoma, Persoon, in South Africa," by PAUL A. V. D. BIJL.

19. " On a fungus Ovulariopsis Papayae n. sp. which causes Powdery

Mildew on the Leaves of the Pawpaw Plant (Carica Papaya Linn.)," by Paul A. v. d. Bijl.

20. "South African Xylarias occurring around Durban, Natal," by Paul A. v. d. Bijl.

21. "Note on the Spinal Reactions of the Platana," by W. A. Jolly.

22. "A possible Lunar Influence upon the Velocity of the Wind at Kimberley. (Third Paper)," by J. R. Sutton.

23. "Note on Lysurus Woodii (MacOwan) Lloyd," by Paul A. v. d. Bijl.

24. "A Prehistoric Rock-Sculpture from the North-Eastern Transvaal," by C. Pijper.

25. "Colour and Chemical Constitution. Part XII.: The Calculation of Colour from the Tautomeric Theory," by James Moir.

26. "A possible Lunar Influence upon the Velocity of the Wind at Kimberley. (Fourth Paper)," by J. R. Sutton.

27. "On the Integrated Velocity Equations of Chemical Reactions," by J. P. Dalton.

28. "Medical Folklore of the Abantu in the Lijdenburg District," by Cornelis Pijper.

29. "The Action of Urginea Burkei," by J. W. C. Gunn.

30. "A Revision of the South African Agamas related to Agama hispida, A. atra, and A. anchietae," by G. A. Boulenger and J. H. Power.

31. "A Species of Microdon (Diptera) from Natal," by S. H. Skaife.

32. "Observations on Living Fish brought by H.M.S. *Challenger* from Tropical East Africa to Cape Waters," by J. D. F. Gilchrist.

33. "Detection of Induced Beta-ray Emission from Substances Exposed to Röntgen Rays by a Photographic Method. (Preliminary Paper)," by Lewis Simons.

34. "A Contribution to the Study of the Rainfall Map of South Africa," by J. R. Sutton.

35. "Some Notes on Ancient Ideas concerning the Diamond," by J. R. Sutton.

36. "Experimental Infectation of Fresh-water Snails," by F. G. Cawston.

37. "The Water Relations of the Pine (P. pinaster) and Silver Tree (Leucadendron argenteum)," by R. D. Aitken.

38. "The Action of Eucomis Undulata (Preliminary Communication)," by J. W. C. Gunn.

39. "A Study of the Bacillus Coli Group, with Special Reference to the Serological Characters of these Organisms," by T. J. Mackie.

40. "Note on Over-Voltages," by E. Newbery.

Vol. VIII., Parts 2, 3, and 4, of the Society's Transactions have been issued during the year.

The following have been elected Fellows in 1920: Keppel Harcourt Barnard, M.A.; J. W. Bews, M.A., D.Sc.; Mrs. Frank Bolus, B.A.; John Patrick Dalton, M.A., B.Sc., D.Sc.; and Thomas Jones Mackie, M.B., Ch.B., D.P.H.

The number of Honorary Fellows is 3, Fellows 51, Members 165.

The Society regrets to have to record the deaths, since the 1920 Anniversary Meeting, of Sir Kendal Franks, Fellow, and Sir Maitland H. Park, Member.

The following members have resigned: G. A. K. Marshall, Hon. P. A. Methuen, F. W. Pettey, P. Lindsay Sandes, and F. B. Smith. Three names were struck off the roll during the year.

Additional shelving has been kindly lent by the University of Cape Town for the Royal Society library, and this has rendered possible a rearrangement of the library, which has been made during the year. It is extremely desirable that many of the periodicals should be bound, and it is hoped that this can soon be proceeded with.

Some publications which have been missing since the commencement of the war have arrived during the year.

TREASURER'S ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1920.

REVENUE.

	£	s.	d.	£	s.	d.
To Subscriptions received in 1920:						
for 1917, 1 Fellow	2	0	0			
for 1918, 1 Fellow at £2, 1 Town Member at £2, 4 Country Members at £1 ..	8	0	0			
for 1919, 2 Fellows at £2, 5 Town Members at £2, Balance 1 Town Member at £1, 18s., 14 Country Members at £1	29	18	0			
for 1920, 46 Fellows at £2, 45 Town Members at £2, Balance 1 Town Member at £1, 18s., 90 Country Members at £1 ..	273	18	0			
for 1921, 1 Fellow at £2, Part 1 Fellow at 2s., 1 Town Member at £2, Part 1 Town Member at 2s., Part 1 Country Member at 1s.	4	5	0			
				318	1	0
,, Entrance Fees				6	0	0
,, Sale of Publications to Government				100	0	0
,, Sale of Publications otherwise				12	5	1
,, Sale of Extra Reprints of Papers				8	2	0
,, Government Grant, 1920–1				300	0	0
,, Interest on Fixed Deposit, £800, at Standard Bank at 4½ per cent., less 4s. for Stamps on renewing deposit				33	16	0
,, Interest on £400 Union of South Africa 5 per cent. Stock				20	0	0
,, Interest on Money in Savings Bank Department of Standard Bank				6	3	1
				£804	7	2

EXPENDITURE.

	£	s.	d.	£	s.	d.
By Publications				521	2	3
,, International Scientific Catalogue of papers:						
Compilation	25	0	0			
Cartage for parts sent as goods	0	2	4			
Copy of Physical Anthropology, 14th Issue	0	14	4			
				25	16	8
,, Clerical Assistance and Work in Library ..				57	0	0
,, Local Printing and Stationery				53	18	6
,, Postages and Petties				16	1	4
,, Bank Charges for Commissions, Ledger Fees, etc.	4	1	6			
Less Commissions paid by Members ..	2	4	0			
				1	17	6
,, Hire of Rooms for Meetings, Caretaker, 1920				6	6	0
,, Insurance of Library, Premium 1920–1 ..				0	10	6
,, Binding Periodicals in Library				14	2	6
,, Excess of Revenue over Expenditure ..				107	11	11
				£804	7	2

ASSETS AND LIABILITIES AS AT DECEMBER 31, 1920.

Assets.*	£	s.	d.
Money at Standard Bank on Fixed Deposit at 5 per cent. ..	800	0	0
Money in Savings Bank Department of Standard Bank ..	273	18	4
Balance at Standard Bank, as per Pass Book	167	5	6
Union of South Africa 5 per cent. Stock (1921–1936)	400	0	0
Arrears of Subscriptions, as in Statement for 1919, £57, 18s., *less* £39, 18s. paid in year and £15 struck off as irrecoverable	3	0	0
Arrears—Entrance Fee and Subscriptions for 1920	44	0	0
	£1688	3	10

Liabilities.	£	s.	d.
Subscriptions, whole or in part, received for 1921	4	5	0
Research Grant unpaid in part: Professor J. T. Morrison..	80	0	0
Publication of Transactions, estimated	250	0	0
Contribution towards Paper in Vol. VIII., Part 4 (in last year's statement as Vol. VIII., Part 2 or 3)	75	0	0
Binding Periodicals in Library	16	15	0
Salary due to Assistant Librarian, Cheque not cashed by December 31	5	0	0
Earmarked for Expense of Publishing, as a part of the Transactions, a Reproduction of a Bushman Painting (Council Minutes, May 12, 1915), a sum not exceeding	350	0	0
Balance from 1912 Conversazione carried forward towards the expenses of future Conversazione in Cape Town ..	7	4	0
Capital at December 31, 1920, being excess of Assets over Liabilities	899	19	10
	£1688	3	10

* Exclusive of value of Library and Publications of the Society held in stock.

Entrance Fees and Life Subscriptions Fund, 1920.

	£	s.	d.
Amount of Fund at January 1, 1920	246	0	0
Received in 1920 from Entrance Fees	6	0	0
	£252	0	0

	£	s.	d.
Amount of Fund at December 31, 1920	252	0	0
	£252	0	0

We hereby certify that we have examined the above balance and revenue accounts with the books, vouchers, and Banker's pass books relating thereto, and that, in our opinion, they correctly set forth a true and correct statement of the affairs of the Society.

S. S. HOUGH.
W. N. ROSEVEARE.

February 21, 1921.

An Ordinary Meeting was held on Wednesday, April 20, 1921, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

Business :—

The Minutes of the previous meeting were confirmed.

Miss M. R. MICHELL, B.A., was elected to membership.

The following were nominated for membership : Mr. G. S. SHORTRIDGE, proposed by Dr. L. PÉRINGUEY, seconded by the Hon. General Secretary ; MR. HOWARD FERGUSON, proposed by Mr. C. W. MALLY, seconded by Dr. C. F. JURITZ ; Dr. F. G. CAWSTON, proposed by Dr. L. PÉRINGUEY, seconded by the Hon. General Secretary ; and Mr. A. F. BEARPARK, proposed by the President, seconded by the Hon. General Secretary.

A demonstration was given of "Bushman Implements," by Dr. L. PÉRINGUEY.

Dr. Péringuey showed examples of a peculiar instrument, consisting of a piece of stone fastened by gum cement to a short handle of wood. These are similar to the implement described by Mr. John Hewitt at the last meeting of the Society as a Fire-flint of Strandlooper origin. An explanation which has been given by Dr. Péringuey of this type of instrument is that it may be considered a baton de commandement, denoting superiority of the owner as medicine-man or chief, or alternatively that it may represent an attempt to make an uncouth stone implement more serviceable by hafting. Dr. Péringuey considers that the flint fire-striking theory must be abandoned, as this would entail a violent blow on steel, and the attachment could not have resisted a moderate blow without giving way.

The following communications were made :—

"On the Reptilian Genera Euparkeria Broom and Mesosuchus Watson," by S. H. HAUGHTON, B.A.

The paper describes and figures portions of further skeletons of the genera *Euparkeria* and *Mesosuchus* recently discovered in the "Alfred Brown Collection" acquired by the South African Museum. The specimens add considerably to our knowledge of these two interesting genera. Certain bones described by Broom as *Browniella africana* are considered to belong to the genus *Euparkeria*. *Mesosuchus* is shown to be very closely allied with *Howesia* in the structure of the limbs and pelvis ; and the carpus and tarsus are described for the first time.

"Note on the South African Elephant," by L. PÉRINGUEY.

The author describes elephants which have been obtained from the Addo Bush. Lyddeker considers that the Addo Bush elephant differs in several points from the Central African and even from the Knysna elephant.

The present author is not inclined to share this view, but if it is correct, the difference may be due to the progeny of a long-lived bull dominating the herd. The period of gestation of the elephant is not known with certainty, but a cow with a sucking calf about the height of a donkey was found to be in an advanced state of pregnancy, the fœtus being completely formed and 1 foot 11 inches in height, and length of body, minus head, 1 foot 9 inches. The mother's udders were full of milk.

"Note on Whales," by A. F. Bearpark (communicated by the President).

The author discusses the note on Whales by Péringuey (*Transactions*, Vol. IX, Part 1) and criticises Dr. Péringuey's use of the jaw-bone as a basis for estimating the size of a whale, and questions the correctness of the statement made in that paper regarding the occurrence of Balaenoptera borealis in northern seas. The author also traverses Dr. Péringuey's assertions about the feeding habits of whales, and points out that the existence of the alleged os penis in Megaptera longimana requires confirmation. A photograph is submitted demonstrating that the sternum of Balaenoptera borealis shown by Dr. Péringuey as typical of the species is really an abnormal specimen.

"Sunspots and Earth Temperatures," by J. R. Sutton.

This paper gives the results of a comparison between the earth temperatures observed at Kimberley, Córdoba, and Adelaide, with Wolfer's observed sunspot numbers. In all three cases the tendency is for a higher temperature to accompany a lower spot number. The differences, however, are small in the case of Kimberley and Adelaide, and only definite in the summer months. At Córdoba they are much greater, and especially so in the summer. The results, so far as they go, are in agreement with previous ones.

"Rainfall and the Pressure Gradient," by J. R. Sutton.

This paper discusses the possibility that the monthly mean pressure gradient between Kimberley and Cape Town may have some connection with the rainfall of the two places. At Cape Town the rainfall, when the gradient is small, exceeds that when the gradient is large by about 18 per cent. The majority of dry months, and the minority of wet ones, occur with small gradients. At Kimberley it is just the opposite. At Cape Town in the summer, and at Kimberley in the winter, these conditions for any given month incline to continue unaltered into the following month; but at Cape Town in the winter, and at Kimberley in the summer, any given previous month's conditions are reversed. These results, being based on a comparatively short period of observation (12 years), must be regarded as provisional.

" Plants of Bechuanaland," by W. A. Norton.

The paper gives a list of the native names of the plants of Bechuanaland, with the botanical names where these have so far been determined.

An Ordinary Meeting was held on Wednesday, May 18, 1921, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

The following were elected Members of the Society : Mr. G. S. Shortridge, Mr. Howard Ferguson, Dr. F. G. Cawston, and Mr. A. F. Bearpark.

Dr. C. E. Moss was admitted as a Fellow.

The Hon. General Secretary announced that the following are candidates for Fellowship in 1921 : Edwin Percy Phillips, M.A., D.Sc., F.L.S. ; David Thoday, M.A. ; and Robert Harold Compton, M.A.

The following communications were made :—

" Note on the Product of any Determinant and its Bordered Derivative," by Sir Thomas Muir.

" Some South African Stereums," by Paul A. van der Bijl.

The author states that very little attention has thus far been given to the S.A. Fungi belonging to the family Thelephoraceae, of which the largest genus is Stereum, and describes the species collected by him.

" A Fungus—Gibbelula Haygarthii—sp. n.—on a Spider of the Family Lycosidae," by Paul A. van der Bijl.

The author described a fungus belonging to the genus Gibbelula, Cavara, found by Mr. W. Haygarth on a spider. It is evidently an undescribed species, and the author suggests the name G. Haygarthii.

" Circumcision Regiments as a Native Chronology," by W. A. Norton.

This paper deals with Bechuana Circumcision Regiments as native chronology, showing that a military organisation of native tribes based on the successive circumcision companies of the youth was very widespread in Southern Africa, and illustrating by lists of regiments collected from 26 tribes of the Transvaal and Bechuanaland, comprising some 200 names : *e.g.*, the Hyenas, the Elands, the Leopards, the Tramplers, the Scatterers, the Pythons, the Locusts, the Vanguard, the Rooi-baaitjes (*e.g.*, of Major Warden), the Drummers on the Shield : such double names being characteristic of Bechuanaland, not of the Transvaal. In the case of the Baralong

and other tribes, the regiment lists, running back to 1750, indicate where the split between different branches occurred. It is sought to carry them far enough back to illustrate the fission of the now distinct tribes from one another, to which tradition (*e.g.*, the chiefly genealogies) point, but the rapid passing of the old people makes this increasingly difficult and urgent. These lists are of great value to history as well as to philology, as they aid the dating of events much more precisely, as a rule, than do the reigns of chiefs. They also illustrate the temper of the tribe at the time each regiment was named; ill luck produces modesty of nomenclature, and return of prosperity the opposite!

An Ordinary Meeting was held on Wednesday, June 15, 1921, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

In the absence of the President, Dr. A. YOUNG was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

The following were nominated for Membership: Professor E. H. CLUVER, proposed by Professor J. W. C. GUNN, seconded by the Hon. General Secretary; and Mr. H. E. PENROSE, proposed by Mr. S. S. HOUGH, seconded by the Hon. General Secretary.

The following communications were made :—

"A Preliminary Genetic Study on the Osteology of the Griquas," by V. H. BRINK (communicated by the President).

"Note on the Life Period of the Over-voltage Compounds," by EDGAR NEWBERY.

A series of experiments have been carried out to determine the effect of changes in the speed of the commutator upon the measured over-voltage of various cathodes in dilute sulphuric acid. The commutator was rotated at speeds varying between 300 and 1500 revs. per minute, and an interesting set of curves was obtained by plotting the observed over-voltages against these speeds. Some of the curves are horizontal straight lines, whilst others show more or less fall of measured over-voltage at the lower speeds. All the curves tend to a definite maximum which is but little removed from the greatest value shown, and which has been taken as the true over-voltage. The relative rates of decomposition or decay of the over-voltage compounds is shown by these curves. Those of zinc and chromium are so stable that no perceptible change of potential occurs within the time limits of the experiments. The hydrides of silver, platinum, and graphite show signs of decay after one-twentieth of a second, those of copper and cadmium after

one-thirtieth of a second, whilst those of lead and nickel appear to be decomposed with very great rapidity.

An Ordinary Meeting was held on Wednesday, July 20, 1921, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

In the absence of the President, Dr. A. OGG was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Professor E. H. CLUVER and Mr. H. E. PENROSE were elected Members.

Mr. CECIL LEONARD ROBERTSON, B.Sc., A.M.I.C.E., proposed by Mr. J. S. HENKEL, seconded by the Hon. General Secretary, was nominated for Membership.

The following communications were made :—

"Some Observed Results of the Effect of Sunlight on Lead Storage Cells," by E. J. HAMLIN.

The author has conducted a series of experiments, and shows by means of curves that sunlight has a serious effect not only on efficiency of a lead storage cell, but on the useful life of the cell.

It is estimated that a cell placed in sunlight is 3 per cent. less efficient than a similar cell under identical conditions when the latter is kept away from the direct rays of the sun. The useful life of the cell is diminished by approximately 25 per cent. by the effect of the direct rays of the sun.

"The Effect of Evaporation on the Efficiency of Lead Storage Batteries," by E. J. HAMLIN.

The author gave the results of a test on the battery installed at the Stellenbosch Power Station. By using a "topping" of ½-inch of paraffin he found that the Amp-hour efficiency of his battery was increased by 1·7 per cent. This saving in energy more than paid for the cost of the paraffin used, and materially saved in labour necessary for "topping" the battery with distilled water to counterbalance the effect of evaporation.

"Note on the Pectoral Fin of the Sole—Achirus Capensis," by J. D. F. GILCHRIST.

The pectoral fin, described as absent in this species of sole, is represented by a small vertical fold of epidermis with rudimentary rays, situated on the body below and concealed by the opercular membrane. It functions as an accessory organ in respiration, and illustrates the origin of a new organ. Suggestions are made as to how it may have arisen and become more marked by characters acquired by use and disuse, and as to how these characters ultimately become hereditary.

An Ordinary Meeting was held on Wednesday, August 17, 1921, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Mr. Cecil Leonard Robertson, B.Sc., A.M.I.C.E., was elected a Member.

Professor H. G. Denham, M.A., D.Sc., Ph.D., and Professor E. S. Edie, M.A., B.Sc., were nominated for Membership.

The President announced that the Royal Society proposes to entertain the members of the Shackleton Expedition when they arrive in Cape Town. It was pointed out that the Society has entertained previous expeditions, and the President expressed the hope that the forthcoming visit would arouse public interest in this country in scientific exploration and would lead to additional support for such enterprises.

Demonstration :—

Professor D. Thoday gave a demonstration of a large number of photographs illustrating the Vegetation of South Africa, and described how the vegetation is influenced by many different conditions.

The following communications were made :—

"Note on the Bismuth Sub-salts," by H. G. Denham (communicated by the President).

The basic oxalate of bismuth, when heated to 300 degrees under reduced pressure, yields a dark, pyromorphous powder of the composition of BiO, bismuth suboxide. When the vapour of methyl iodide is distilled through this suboxide at 260 degrees, a basic subiodide, $2BiI_2$, 3BiO is obtained—a reddish, insoluble powder of considerable reducing power. Outside the oven, a crop of bright red, needle-like, ortho-rhombic crystals of bismuth subiodide, BiI_2, separated out. This substance is appreciably soluble in alcohol, methyl iodide, and in an aqueous solution of potassium iodide, yielding in all cases a yellowish-red solution. Both the above salts are quite stable in dry air, but readily oxidise in the pressure of moist oxygen.

"On Variation and Heredity in the Bruchidae," by S. H. Skaife.

The author describes breeding experiments with beetles of the family Bruchidae, which are excellent subjects for experiment, as they couple and oviposit freely in confined spaces and require very little attention throughout their whole life cycle. A mutation was found in *acanthoscelides obtectus* which was lacking in pigment, and this lack of pigmentation was found to be recessive to the normal condition, the simple 3 : 1 ratio being obtained

in the F_2 generation. Experiments are described including attempts to hybridise *chinensis* and *quadrimaculatus*, which were unsuccessful. Interspecific crossing is prevented among the Bruchidae by the remarkable differences in the size, shape, and structure of the internal sacs of the males.

Annual Meeting.

The Annual Meeting was held on Wednesday, September 28, 1921, at 8.15 p.m., in the Department of Physics, University of Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

Business :—

The following candidates were elected Fellows: Robert Harold Compton, M.A.(Cantab.); Edwin Percy Phillips, M.A., D.Sc., F.L.S.; and David Thoday, M.A.(Cantab.).

Ordinary Meeting.

An Ordinary Meeting was held after the Annual Meeting.

The President was in the Chair.

Business :—

The Minutes of the last Ordinary Meeting were confirmed.

Professor H. G. Denham, M.A., D.Sc., Ph.D., and Professor E. S. Edie, M.A., B.Sc., were elected Members.

Professor J. M. Watt, M.B., Ch.B., proposed by Professor J. W. C. Gunn, seconded by the Hon. General Secretary, was nominated to Membership.

Demonstration :—

"Alpha Rays from Polonium," by Mr. C. W. v. d. Merwe, B.A.

The speaker began by referring to Aitken's condensation experiments: Aitken found that the presence of little dust particles—dust nuclei—in a space containing water vapour, facilitate the process of condensation. Theoretical considerations demand that condensation should take place more readily on a flat surface than on a convex one, on account of the influence of surface tension in the latter case, and that the greater the convexity of the surface the more efficient should surface tension be in preventing condensation. The presence of dust particles then provides

nuclei of finite dimensions, and by effecting a comparatively small degree of supersaturation the effect of surface tension may be overcome and condensation take place.

C. T. R. WILSON showed that the same result could be arrived at by charging the nucleus: that if condensation would just not occur on an uncharged nucleus on account of its smallness, then under exactly the same conditions the condensation would occur if the nucleus were given a charge.

The principle was used by WILSON in photographing the tracks of a particles: the particles were projected into a space saturated with water vapour; by suddenly increasing the volume of the space supersaturation was effected and condensation took place on the ions formed by the passage of the a particles through the air. The ions were so densely packed along the path of the particles, that the vapour condensed on these ions gave the track the appearance of being absolutely continuous.

The speaker then showed some negatives he had taken; these were projected on a screen and illustrated the tracks of a particles in various gases such as air, nitrogen, oxygen, carbon monoxide, carbon dioxide, nitric oxide, sulphur dioxide, methyl bromide, hydrogen, and methane.

Attention was drawn to certain characteristics of the tracks, the deviation in the track towards the end of the range being especially marked in some cases.

After this, those present were taken into the laboratory and were afforded the opportunity of seeing the tracks for themselves.

Demonstration:—

"A Tooth of Elephas cf. Antiquus from the Vaal River Gravels," by Mr. S. H. HAUGHTON, B.A.

The anterior half of a lower third molar of a large elephant from the Bend, Vaal River, was exhibited. The specimen is closely comparable with *Loxodonta antiquus* and is the most southerly representative of that form. Comparisons were made, with other Loxodonts. The specimen is the property of the Kimberley Museum.

The following communications were made:—

"Colour and Chemical Constitution. Part XV.: A Systematic Study of Fluorescein and Resorcin-Benzeine," by JAMES MOIR.

Following the method of Part XI., colour-factors have been obtained by experiment whereby the colour of any halogenated fluorescein, substituted in any of the ten possible positions, can be calculated. The position of the absorption band in forty-six derivatives of fluorescein is given.

A preliminary investigation of resorcin-benzeine involving fourteen derivatives follows.

"On the Origin of Paired Fins in Fishes," by J. D. F. GILCHRIST.

An Ordinary Meeting was held on Wednesday, October, 19, 1921, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Professor J. M. WATT, M.B., Ch.B., was elected to Membership.

The Hon. General Secretary announced the Council's recommendation for Officers and Council for 1922, as follows :—

President : Dr. J. D. F. GILCHRIST ; Hon. Treasurer : Dr. L. CRAWFORD ; Hon. General Secretary : Dr. W. A. JOLLY ; Sir CARRUTHERS BEATTIE, Mr. S. H. HAUGHTON, Mr. S. S. HOUGH, Dr. C. J. JURITZ, Mr. C. P. LOUNSBURY, Professor J. T. MORRISON, Dr. A. OGG, Dr. A. W. ROGERS, and Dr. R. B. YOUNG.

The following Fellows were admitted :—

Professor DAVID THODAY, M.A., and Professor ROBERT HAROLD COMPTON, M.A.

The following communications were made :—

"Some Observations on the Effect of Fire on the Vegetation of Signal Hill," by Miss M. R. MICHELL.

The bush fire, the effects of which were recorded, broke out early in February 1919, killing all the aerial parts of plants. Within three weeks a few plants had put up vigorous shoots—notably *Asparagus capensis.* This species flowered about six weeks earlier than usual that year.

The shrubs which had occupied the area were perpetuated in two ways : (*a*) by regeneration from the underground parts, *e.g.*, all species of *Rhus*, and (*b*) by seed, *e.g.*, the Rhenoster bush. In general, a given species followed one of these methods only.

A large number of plants possessed underground resting organs, *e.g.*, *Sparaxis grandiflora, Oxalis variabilis.* These, with the exception of *Babiana stricta*, were far more abundant than usual and their flowers were finer. Suggestions were made as to the way in which the fire had brought about this result.

The northern and southern slopes of the valleys showed marked differences in vegetation especially in the winter months. This was attributed to differences of illumination.

The fire encouraged the process of erosion, the influence of man and cattle being contributory. The fire was favourable to the spread of the Rhenoster bush. No evidence of eradication of species by burning was obtained.

The vegetation of the area, which has a soil derived from the Malmesbury

Slates, showed marked differences from that on the southern end of Signal Hill, where the soil is of granitic origin.

"On the Morphology of Selaginella Pumila," by Miss A. V. Duthie.

This paper treats of the external morphology and anatomy of the vegetation organs of Selaginella pumila. The species is an annual one and confined to South Africa. It is usually looked upon as rare, but occurs in abundance on the flats and hill-slopes in the neighbourhood of Stellenbosch. Though hitherto considered as a typical isophyllous species with radial symmetry, an approach to dorsiventrality and anisophylly is occasionally met with. The somewhat prominent base of the vegetative leaf contains well-defined aerenchyma communicating with the atmosphere by means of a group of stomata. Stomata are confined to the aligular surface of the leaf and the leaf margin. The protoxylem of the leaf is usually accompanied by two lateral strands of transfusion tracheides which may link up with the tracheal sheath of the ligule. The roots are destitute of root hairs, and contain an endophytic fungus. An air space is present in the root cortex on the phloem side of the stele.

"Note on a Specimen of Phacops Africanus, Lake," by A. R. E. Walker.

A nodule was exhibited which contained both an internal cast and a mould of the external surface of the thorax, and tail of a trilobite individual referred to Phacops africanus, Lake. A cast in gelatine from the external mould clearly showed that each segment of the axis of the thorax bore a strong medium spine. The thorax is regarded as being composed of eleven segments, not—as Lake somewhat doubtfully states—ten.

"A Note on the Pharmacological Action of Scilla Cooperi, Hook. Fil., Scilla Rogersii, Baker, and Scilla Lanceafolia, Baker," by J. W. C. Gunn, Morris Goldberg, and J. H. Ferguson.

A preliminary investigation of the action of extracts of these South African species of squill on frogs and mammals (cats and dogs) shows that they all possess the action of the digitalis group, like the official squill, Scilla maritima. As judged by the minimal lethal dose on Xenopus laevis, they are much less poisonous than Scilla maritima, and would probably be of considerably less medicinal value. They all contain glucosides.

I. "On some South African Paramphistomidae" (Fisch).

II. "On some Trematodes in South African Anura and the Relationships and Distribution of their Hosts," by C. S. Grobbelaar.

The first part of the paper deals with observations on Paramphistomids, well-known parasites found in the rumen of sheep and cattle. The conditions favouring natural infection of stock, the effects of infection, and the general distribution of the family in South Africa are noted.

Experimental evidence to establish "Isidora (Physa) tropica" Krauss as the intermediate host of "Paramphistomum caticophorum" Fisch.

Description of the rediae and cercariae—the cercariae are identified as "C. frondosa" (Cawston).

The second part of the paper deals with the frog-trematodes collected by the author in the Cape Province. These trematodes are referred to their systematic positions with brief notes on their occurrence. Finally the author discusses, on the lines laid down by S. J. Johnston, the mutual relationships and distribution of the hosts in the five zoo-geographical regions: Europe, Asia, North America, Australia, and South Africa.

"The 'Account Book' of Jan Haszing," by C. Pijper and H. Zwarenstein.

Jan Haszing practised as a surgeon at Cape Town in the middle of the eighteenth century. His "Account Book," which in some way or other has found its way to the archives at Cape Town, starts at 1736 and runs on continuously till 1767. The extracts given throw light on the life of Cape Town at that epoch.

"Colour and Chemical Constitution. Part XVI.: Further Miscellaneous Observations," by James Moir.

The position of the absorption-band is given for ten further derivatives of benzhydrol, for twelve further derivatives of phenolphthalein, for five derivatives of quinolinic acid, for eleven further triphenyl-carbinol dyes, and for ten other substances connected with colour and fluorescence.

Anniversary Meeting.

The Anniversary Meeting of the Society was held on Wednesday, March 15, 1922, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

The Report of the Hon. General Secretary was submitted and adopted.

The Report of the Hon. Treasurer was submitted and adopted.

The following were elected Members of the Council for the year 1922: Sir Carruthers Beattie, Dr. L. Crawford, Dr. J. D. F. Gilchrist, Dr. S. H. Haughton, Mr. S. S. Hough, Dr. W. A. Jolly, Dr. C. F. Juritz, Mr. C. P. Lounsbury, Professor J. T. Morrison, Dr. A. Ogg, Dr. A. W. Rogers, and Dr. R. B. Young.

Dr. J. D. F. Gilchrist was elected President; Dr. L. Crawford, Hon. Treasurer; and Dr. W. A. Jolly, Honorary General Secretary.

Ordinary Meeting.

An Ordinary Meeting was held after the Anniversary Meeting.

The President was in the Chair.

The Minutes of the last Ordinary Meeting were confirmed.

Mr. F. Hirschhorn, proposed by Miss M. Wilman, seconded by Dr. J. R. Sutton, was nominated for Membership.

Dr. Percy A. Wagner was admitted to Fellowship.

Report of the Hon. General Secretary for 1921.

Eight Ordinary Meetings, the Annual Meeting, and the Anniversary Meeting were held during the year, and the following papers were read :—

1. " The Permanganate Absorption Spectrum : A Claim for Priority. (2) Formula for Calculating the Uranium Spectrum," by James Moir.
2. " Colour and Chemical Constitution. Part XIII. : The Calculation of the Colour of the Monocyclic Dyes," by James Moir.
3. " Colour and Chemical Constitution. Part XIV. : The Calculation of the Colour of the Dicyclic Dyes," by James Moir.
4. " The Crystalline Structure of Antimony and Bismuth," by A. Ogg.
5. " On Braula Caeca, Nitzsch, a Dipterous Parasite of the Honey Bee," by S. H. Skaife.
6. " Notes on the Development of the Ovule, Embryo Sac, and Embryo of Hydnora Africana (Thunb.)," by R. H. Dastur.
7. " Note on a Fire-flint of Strandlooper Origin," by John Hewitt.
8. " A Note on the Use of the South African Clawed Toad in the Biological Assays of the Digitalis Series," by J. W. C. Gunn.
9. " On the Reptilian Genera Euparkeria Broom and Mesosuchus Watson," by S. H. Haughton.
10. " Note on the South African Elephant," by L. Péringuey.
11. " Note on Whales," by A. F. Bearpark (communicated by the President).
12. " Sunspots and Earth Temperatures," by J. R. Sutton.
13. " Rainfall and the Pressure Gradient," by J. R. Sutton.
14. " Plants of Bechuanaland," by W. A. Norton.
15. " Note on the Product of any Determinant and its Bordered Derivative," by Sir Thomas Muir.
16. " Some South African Stereums," by Paul van der Bijl.
17. " A Fungus—Gibbelula Haygarthii—sp. n.—on a Spider of the Family Lycosidae," by Paul van der Bijl.
18. " Circumcision Regiments as a Native Chronology," by W. A. Norton.

19. "A Preliminary Genetic Study of the Osteology of the Griquas," by V. H. BRINK (communicated by the President).

20. "Note on the Life Period of the Over-voltage Compounds," by EDGAR NEWBERY.

21. "Some observed Results of the Effect of Sunlight on Lead Storage Cells," by E. J. HAMLIN.

22. "The Effect of Evaporation on the Efficiency of Lead Storage Batteries," by E. J. HAMLIN.

23. "Note on the Pectoral Fin of the Sole-Achirus Capensis," by J. D. F. GILCHRIST.

24. "Note on the Bismuth Sub-salts," by H. G. DENHAM.

25. "On Variation and Heredity in the Bruchidae," by S. H. SKAIFE.

26. "Alpha Rays from Polonium," by C. W. v. D. MERWE.

27. "Colour and Chemical Constitution. Part XV.: A Systematic Study of Fluorescein and Resorcin-benzeine," by JAMES MOIR.

28. "Some Observations on the Effect of Fire on the Vegetation of Signal Hill," by Miss M. R. MICHELL.

29. "On the Morphology of Selaginella Pumila," by Miss A. V. DUTHIE.

30. "Note on a Specimen of Phacops Africanus, Lake," by A. R. E. WALKER.

31. "A Note on the Pharmacological Action of Scilla Cooperi, Hook, Fil., Scilla Rogersii, Baker, and Scilla Lanceaefolia, Baker," by J. W. C. GUNN, MORRIS GOLDBERG, and J. H. FERGUSON.

32. "I. On some South African Paramphistomidae (Fisch). II. On some Trematodes in South African Anura and the Relationships and Distribution of their Hosts," by C. S. GROBBELAAR.

33. "The 'Account Book' of Jan Haszing," by C. PIJPER and H. ZWARENSTEIN.

34. "Colour and Chemical Constitution. Part XVI.: Further Miscellaneous Observations," by JAMES MOIR.

35. "On the Origin of paired Fins in Fishes."

Vol. IX, Parts 1, 2, 3, and 4; and Vol. X, Part 1, of the Society's Transactions have been issued during the year.

The following have been elected Fellows in 1921: R. H. COMPTON, M.A.; E. P. PHILLIPS, M.A., D.Sc., F.L.S.; DAVID THODAY, M.A.

The number of Honorary Fellows is 3; Fellows, 55; Members, 170.

The deaths, since the 1921 Anniversary Meeting, of H. C. SCHUNKE-HOLLWAY, Fellow of the Society and Member of the S. A. Philosophical Society from 1878; and J. HUTCHEON, Member, are recorded with regret.

Two Fellows and seven Members are resigning from the end of the year, and two Members were struck off the roll during the year.

REVENUE AND EXPENDITURE ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1921.

Revenue.

	£	s.	d.	£	s.	d.
To Subscriptions for 1921 :						
Subscriptions collected for years before 1920	8	0	0			
Subscriptions collected for 1920	26	0	0			
,, ,, ,, 1921	262	16	0			
,, ,, ,, 1922	4	13	0			
Life Membership Subscription	25	0	0			
Subscriptions for 1921 collected in 1920	4	5	0			
Outstanding Subscriptions at December 31, 1921	75	19	0			
	406	13	0			
Less : Outstanding Subscriptions at December 31, 1920, £47, and Subscriptions for 1922 collected in 1921, £4, 13s.	51	13	0			
				355	0	0
,, Entrance Fees				14	0	0
,, Government Grant, 1921–2				300	0	0
,, Interest on Fixed Deposit, £800, at Standard Bank for 1 year at 5 per cent.				40	0	0
,, Interest on £400 Union of South Africa 5 per cent. Stock				20	0	0
,, Interest on Money in Savings Bank Department of Standard Bank				4	1	8
,, Refund, part 1917 Research Grant to Professor Morrison				20	0	0
,, Balance of 1917 Research Grant to Professor Morrison, written off				80	0	0
, Loss in year 1921				454	3	5
				£1287	5	1

Expenditure.

		£	s.	d.	£	s.	d.
By Publications :							
,, Cash paid for Publications in year		1407	19	4			
Less : Contribution for Paper in Vol. VIII, Part 4	£75 0 0						
Receipts for Sale of Publications	104 12 2						
Receipts for extra Reprints of Papers	134 5 6						
Amount due for extra Reprints of Papers	8 14 9						
Amount paid for Publications of 1920	250 0 0						
		572	12	5			
		835	6	11			
,, Amount due at December 31, 1921, for publications		252	10	3			
					1087	17	2
,, Compilation of International Catalogue of Scientific Papers					25	0	0
,, Clerical Assistance and Work in Library					65	0	0
,, Local Printing and Stationery					82	1	3
,, Postages and Petties					19	15	2
,, Bank Charges for Commissions, Ledger Fee, Fixed Deposit, Stamps, etc		2	11	0			
,, *Less* Commission paid by Members		1	16	0			
					0	15	0
,, Hire of Rooms and Caretaker, 1921					6	6	0
,, Insurance of Library, 1921–2					0	10	6
					£1287	5	1

Entrance Fees and Life Subscriptions Fund

	£	s.	d.		£	s.	d.
Amount of Fund at January 1, 1921	252	0	0	Amount of Fund at December 31, 1921	291	0	0
Entrance Fees received in 1921	14	0	0				
Life Subscription received in 1921	25	0	0				
	£291	0	0		£291	0	0

ASSETS AND LIABILITIES AT DECEMBER 31, 1921.

Assets.*

	£	s.	d.
Money at Standard Bank on Fixed Deposit for one year at 5½ per cent.	500	0	0
Money in Savings Bank Department of Standard Bank	48	0	0
Balance at Standard Bank as per Pass Book	44	17	8
Union of South Africa 5 per cent. Stock (1921–36)	400	0	0
Arrears of Subscriptions, as in Statement for 1920, £47, *less* £28 paid in year 1921, and £4 struck off as irrecoverable	15	0	0
Arrears of Subscriptions for 1921, £62, 19s., *less* £2 struck off as irrecoverable	60	19	0
Accounts due for extra Reprints of Papers	8	14	9
	£1077	11	5

Liabilities.

	£	s.	d.	£	s.	d.
Subscriptions, whole or in part, received for 1922				4	13	0
Publication of Transactions				252	10	3
Binding Periodicals in Library				16	15	0
Earmarked for Expense of Publishing, as a part of the Transactions, a Reproduction of a Bushman Painting (Council Minutes, May 12, 1915), a sum not exceeding				350	0	0
Balance from 1912 Conversazione carried forward towards the expenses of future Conversazione in Cape Town				7	4	0
Carriage for Transactions sent to Society, cheque not cashed December 31				0	12	9
Excess of Assets over Liabilities:						
Amount at December 31, 1920	£899	19	10			
Deduct loss in year 1921	454	3	5			
				445	16	5
				£1077	11	5

* Exclusive of value of Library and Publications of the Society held in stock.

We hereby certify that we have examined the above balance and revenue accounts with the books, vouchers, and Banker's pass books relating thereto, and that in our opinion they correctly set forth a true and correct statement of the affairs of the Society.

WM. BAXTER.
A. OGG

February 21, 1922.

The following Communications were made :—

"The Soils of the Hartebeestpoort Irrigation Area (Pretoria and Rustenburg Districts)," by B. DE C. MARCHAND and B. J. SMIT (communicated by Dr. C. F. JURITZ).

"The Trend of Radio-development," by H. E. PENROSE.

The author discussed the various methods which have been adopted for wireless transmission, pointing out the advantages and disadvantages of each and comparing them with the three electrode thermionic valve method. The author also discussed direction-finding and the possibilities of transmitting a beam of wireless waves in any given direction.

"A Study in Charcoal, being a Research on Charcoals made from Exotic Woods grown in the Union of South Africa," by W. S. H. CLEGHORNE (communicated by the President).

The object of the research was to endeavour to classify the different charcoals by the following methods :—

(1) Proximate analysis of the charcoal; (2) measurement of the fuel consumption per brake horse-power on suction gas-engine trial at constant given load for six hours' run; (3) analysis of the gas from the gas producer while the engine was on the trial; (4) measurement of the weight of each charcoal per given volume; (5) the discovery of any consistent relationships between the various quantities measured. Excellent results were obtained from *Acacia saligna*, the common Port Jackson wattle of the Cape Flats.

"Some Notes on the Differentiation of Closely-allied Schistosomes," by F. G. CAWSTON.

The author finds that specimens of fresh-water snails are occasionally encountered which are infested with the cercariae of more than one species of trematode. There are conditions under which schistosomes may develop in other than their common intermediary host. A determination of the number of pairs of mucin glands is one of the most reliable means of determining the species to which a cercaria belongs.

An Ordinary Meeting was held on Wednesday, April 19, 1922, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. A. OGG was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Mr. F. HIRSCHHORN was elected to Membership.

Dr. H. J. VAN DER BIJL, proposed by Dr. C. LAWRENCE HERMAN, seconded by the Hon. General Secretary, was nominated for Membership.

The following communications were made :—

"Fungi of the Stellenbosch District and Immediate Vicinity," by P. A. van der Bijl.

The paper contains a list of the fungi occurring in the Stellenbosch District, with the exception of the Agariceae. The author believes that lasting benefit is to be derived from the close study of the fungi occurring over limited areas.

"Note on the Bronze-brass Industry among South African Aborigines," by L. Péringuey.

The author described a large number of bronze and brass implements, including bracelets, spear-heads, etc., made by South African natives. The analysis of the various alloys used was given, and the author discussed how far the use of bronze and brass had been discovered by the Aborigines, and how far it had been introduced from outside.

"On a Minor Improvement in the Multi-range Potentiometer," by W. H. Logeman.

The author describes a modification of the usual form of potentiometer which leads to greater convenience in its use.

An Ordinary Meeting was held on Wednesday, May 17, 1922, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Dr. H. J. van der Bijl was elected to Membership.

It was announced that the Council recommends for special election as a Fellow, in accordance with Chapter I, Section XIII of the Statutes, the Hon. Sir Ebenezer John Buchanan, formerly Senior Puisne Judge, Supreme Court, C.C.; at one time Member of the House of Assembly; Judge of Supreme Court of Cape of Good Hope from 1880 till retirement; on several occasions Acting Chief Justice of Cape Colony; in four sessions President of the Legislative Council; Member of Council of University of Cape of Good Hope from 1888 to 1918, and Vice-Chancellor 1901–5; Member of the S.A. Philosophical Society from its foundation; Member of that Society and of the Royal Society of South Africa for 45 years.

The certificate of Election was read and allowed by the Society, and it was announced that the election will take place at the next Meeting on June 21.

It was also announced that Dr. Jan Stephanus van der Lingen,

B.A., Ph.D., proposed by ALEXANDER BROWN, ANDREW YOUNG, J. HALM, and JOHN P. DALTON, is a candidate for Fellowship.

The following communications were made :—

"The Control of Evaporation by the Temperature of the Air," by J. R. SUTTON.

The observations discussed in this paper deal with the evaporation from the surface of the water contained in a metal gauge sheltered by a louvred screen. The rates of evaporation accord better with the air temperatures than they do with those of the water. The common formula $E=n\ (V-v)$ fails to express the observed facts, but is improved by substituting p for V, where p is the vapour pressure at the temperature of the free air. Other things being equal, the rate of evaporation increases as the air temperature rises above that of the water. In the space just above the water the relative humidity is much higher than, while the temperature there is about the same as, that of the free air. The evaporating surface is warmed more by contact with the air than it is cooled by evaporation. The results are further illustration of the general law that water vapour diffuses along the relative humidity gradient.

"Note on a Determinant with Factors like those of the Difference-product," by Sir THOMAS MUIR, F.R.S.

"Colour and Chemical Constitution. Part XVII.: The Azo Dyes and other Monocyclic Colours," by JAMES MOIR.

As a result of the author having been presented with a spectrophotographic apparatus, the apparently hopeless problem of the azo dyes has been cleared up. Replacing N by CH and eliminating N or CH, they become calculable from oxy- and amino-benzaldehyde, previously calculated in Part XIII. Quinone and its imines also come into the scheme. Each of the substances has six bands, one pair for neutral, another pair for acid, and a third pair for alkaline solution ; all of these are calculated approximately, on the assumption that each band connotes an independent (tautomeric) chemical formula.

An Ordinary Meeting was held on Wednesday, June 21, 1922, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. C. F. JURITZ was in the Chair.

The Minutes of the previous Meeting were confirmed.

The Hon. Sir EBENEZER JOHN BUCHANAN was elected a Fellow.

It was announced that Dr. ERNEST JOHN HAMLIN, proposed by HERMANN BOHLE, ALEXANDER BROWN, ANDREW YOUNG, and B. DE ST. JEAN VAN DER RIET, is a candidate for Fellowship.

A resolution was proposed and adopted by the Meeting that the Council should endeavour to re-establish a research grant fund in connection with the Society, and should approach Government, or take such other steps as may be desirable for promoting this object.

The following communications were made :—

"On some Upper Beaufort Therapsida," by S. H. HAUGHTON.

The author describes a new genus of Cynodont reptile, *Cynidiognathus*, for the species *C. longiceps*, based on a skull from the Burghersdorp Beds. Its dental formula is i4c1m10. Among interesting features displayed by the skull are the presence of well-marked palatine processes of the premaxillae, the absence of prevomers, and the retraction of the epipterygoid from the quadrate. The brain-case has been exposed and the nature of the dorsal surface of its floor is described.

A skull formerly thought to be *Cynognathus berryi* is assigned to this new genus under the name of *C. broomi*.

The palate and basicranium of *Aelurosuchus* is also discussed and the genus shown to belong to the Bauriamorpha.

"Observations of the Protective Action of Normal Serum in Experimental Infection with Bacillus Diphtheriae," by T. J. MACKIE.

The communication deals with an experimental study of the protection conferred by the parenteral injection of normal serum in animals experimentally infected with B. diphtheriae. The main conclusions arrived at were as follows: (1) in guinea-pigs experimentally infected with B. diphtheriae, normal serum from various animals (horse, ox, sheep, rabbit, cat, man) injected subcutaneously at the same time as the inoculation, exerts a definite protective action; (2) 1 c.c. of normal horse serum may protect in this way against 6 M.L.D. of a B. diphtheriae culture; (3) no protection occurs if the serum injection is delayed for two hours after the inoculation—the effect is prophylactic, not curative; (4) the activity of the serum persists at 57° C., but is lost at 70° C. and higher temperatures; (5) serum from one guinea-pig injected subcutaneously into another is either fully protective to the latter experimentally infected with B. diphtheriae, or at least exerts a definite delaying effect on the course of the infection; it is a matter of considerable interest that the serum of one individual of an animal species, which is highly susceptible to experimental B. diphtheriae infection, should be capable of affording some protection when injected parenterally (in certain amounts) into another animal of the same species infected with the particular organism; (6) normal horse serum is also protective in guinea-pigs injected with diphtheria toxin—1 c.c. may protect against at least 1 M.L.D.; (7) the serum of one guinea-pig is not protective in the case of another injected with diphtheria toxin; (8) in the case of animals surviving after protection by normal

serum, a marked local necrotic lesion develops at site of inoculation (from which B. diphtheriae is absent)—serum is not protective against the local toxic effect.

This study is of interest in its bearing on the general question of "non-specific immunisation" by the parenteral injection of alien protein.

"Note on the Electrogram of the Frog's Gastrocnemius Reflexly Excited," by W. A. Jolly.

Records of the electrical change in the gastrocnemius in spinal preparation of Xenopus laevis, when contraction is reflexly elicited by mechanical stimulation of the heteronymous foot, demonstrate that the response of the muscle in this reflex is of the nature of a tetanus.

"Note on a Cystoscopic Irradiator and an Ultra-violet Light Illuminator," by J. S. van der Lingen.

The author described a lens-system, consisting of two quartz lenses and an Iris diaphragm, whereby a field may be illuminated with any desired group of ultra-violet waves only. This apparatus enables one to study the differential physiological effects of the ultra-violet spectrum.

Cystoscopic irradiators :

(i) A quartz-rod or tube is shaped like a cystoscope and the illuminator already described is used to pass the rays into the organs which are to be illuminated. This apparatus only allows the rays to pass out at its spherical tip ; along the length the rays are totally reflected.

(ii) A tube bent into the form of a cystoscope, and having a bulb at the external end containing a small quantity of mercury, is highly evacuated, and is subsequently heated over a Bunsen burner to introduce carbon-monoxide into the tube. The *carbon-monoxide causes the mercury to radiate at a low temperature* when a high frequency field oscillates in a helix placed over the external end of the tube.

An Ordinary Meeting was held on Wednesday, July 19, 1922, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

The Minutes of the previous Meeting were confirmed.

The following were nominated for Membership: Professor Theodore le Roux, B.A., Litt.D., proposed by Dr. J. S. v. d. Lingen, seconded by the Hon. General Secretary: and Mr. Basil F. J. Schönland, M.A., proposed by Professor A. Ogg, seconded by the Hon. General Secretary.

A letter was read from Sir Ebenezer John Buchanan, thanking the

Society for having elected him a Fellow, and saying, "I believe I am the only surviving original Member of the Society, and have been a subscriber for about fifty years."

Demonstration :—

"Of Maps Illustrating the Zoological Aspects of Wegener's Disruption Hypothesis," by Mr. K. H. Barnard, M.A., F.L.S.

If, after further research, the disruption hypothesis advocated by Wegener were proved to be feasible on geophysical and geological grounds, then the explanation of the distribution of certain groups of animals (and plants) would be very much simplified. The maps showed the unity of the Southern Continents in Palaeozoic times, when the "Gondwanic group" of animals either arose or were in existence, and the effects of their disruption in later geological periods. Stress was laid on the fact that on this hypothesis the land bridges connecting the Southern Continents into an enormous more or less equatorial continent were not required; that, on the contrary, the greater part of the old polar Gondwanaland was still in existence at the present day, and had never been beneath the sea since Palaeozoic times. Consequently the distance over which such groups as, *e.g.*, the Acanthodrile Worms, Peripatopsidae, Acavid Landshells, Cystignathid Frogs had had to travel, was minimised.

The extremities of these continents, hitherto regarded as peripheral, and containing primitive types driven thither by more specialised rivals, are seen to be really portions of the centre of Gondwanaland. The primitive and generalised types have always been approximately where we find them to-day, and their dispersal has been hindered and restricted, other than by physical causes, by the appearance of higher and more dominant types in other regions; *e.g.*, the Acavidae and Achatinidae in South Africa, and Ortman's classical explanation of the mutual exclusiveness of the Fresh-water Crayfishes and Crabs.

The concomitant expansion of an arm of the Indo-Pacific Ocean continually further between India and Australia, Africa and Antarctica, and extending eventually between Africa and South America (to form the Atlantic) was shown to have far-reaching consequences in aiding the dispersal of the marine fauna, *e.g.*, the Silurid Fishes, Galaxias, and the ancestors of the Fresh-water Crayfishes.

Difficulties in the way of explaining certain features of the fauna of New Zealand, which has been permanently above the sea only since Tertiary times, were shown to be obviated by the new hypothesis.

The following communication was made :—

"Note on an Easily Constructed Automatic Toepler Vacuum Pump," by W. H. Logeman.

The author describes a form of automatic Toepler pump which an

amateur glassblower could easily construct and which the author has made. The pump works very well. It can be left working for any length of time, as it requires no watching.

An Ordinary Meeting was held on Wednesday, August 16, 1922, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. GILCHRIST, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

The following were elected to Membership: Professor THEODORE LE ROUX, B.A., Litt.D., and Mr. BASIL F. J. SCHÖNLAND, M.A.

Demonstration :—

"Of a Capillary Electrometer and its Application to Atmospheric Electricity," by Mr. B. F. J. SCHÖNLAND, M.A.

A new form of capillary electrometer, designed by Mr. C. T. R. WILSON, for the measurement of small quantities of electricity and used by him in investigations in atmospheric electricity, was shown. The instrument consists of two threads of mercury in a capillary tube, separated by a small length of a dilute solution of sulphuric acid in water. In this form it works without any gravitational or other control than its own electrostatic one. The sensitivity of the instrument shown was 10^{-9} coulomb, using an observing microscope of magnification 40.

A brief account of the results of WILSON's work on lightning was given. The manner in which the instrument is employed to record instantaneous changes of the vertical electric field by the induced charge on an insulated plate on the surface of the earth was illustrated experimentally.

In the discussion which followed, it was pointed out that South Africa offered exceptional opportunities for investigations on these lines, which have already added enormously to our knowledge of the phenomena involved in thunderstorms.

The following communications were made :—

"The Rhythm of Discharge of the Spinal Centres in the Frog," by W. A. JOLLY.

The author discussed the rate of discharge of the Cord in Xenopus at different temperatures, as indicated by galvanometric records from the gastrocnemius muscle reflexly excited.

"On the Mathematics of the Homogeneous Balanced Action," by JOHN P. DALTON.

In a paper published last year it was shown by the author how the

integrated velocity equations of chemical reactions could be written down in terms of a certain function. The purpose of the present note is to show how the same function may be employed in the treatment of the homogeneous balanced action.

Annual Meeting.

The Annual Meeting was held on Wednesday, September 27, 1922, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

Business :—

The following candidates were elected Fellows : Jan Stephanus van der Lingen, B.A., Ph.D., and Ernest John Hamlin, D.Sc.

Ordinary Meeting.

An Ordinary Meeting was held after the Annual Meeting.

The President was in the Chair.

Business :—

The Minutes of the last Ordinary Meeting were confirmed.

Mr J. A. Gilmore, B.Sc., proposed by Dr. J. Stephanus v. d. Lingen, seconded by the Hon. General Secretary, was nominated for Membership.

Professor H. B. Fantham, M.A., D.Sc., was admitted as a Fellow.

Discussion :—

" The Distribution of Life in the Southern Hemisphere."

The question was discussed from the points of view of Geology, Zoology, Botany, Protozoology, and Entomology.

The following took part : Dr. S. H. Haughton, B.A., D.Sc. ; Professor Andrew Young, M.A., D.Sc.; Mr. K. H. Barnard, M.A.; Professor J. D. F. Gilchrist, M.A., D.Sc., Ph.D. ; Professor H. B. Fantham, M.A., D.Sc. ; Professor J. W. Bews, M.A., D.Sc. ; Professor R. H. Compton, M.A. ; Professor D. Thoday, M.A. ; Dr. A. L. du Toit, B.A., D.Sc. ; Dr. L. Péringuey, D.Sc. ; and Mr. J. Hewitt, B.A.

Contributions to the discussion are appended to the Minutes.

The following communications were made :—

" Some Protozoa found in Soils in South Africa," by H. B. Fantham.

Examination by direct observation and by water-culture of a number of soils from various parts of the Union of South Africa, under varying conditions of cultivation, has shown the presence of Protozoa belonging to the Sarcodina, Mastigophora, and Ciliata. Few trophic Protozoa were detected

in fresh non-waterlogged soils, the organisms occurring mostly in the encysted or resistant condition. Examination of waterlogged soils, such as may be obtained in the rainy season, has shown, in the case of Transvaal soils, the presence of trophic Protozoa. Excess of moisture probably causes excystation. The relative abundance of any one kind of Protozoön in different soils shows considerable variation. The sequence of appearance of the different groups of Protozoa in water-culture is usually Mastigophora, Ciliata, and Sarcodina. The Ciliata appear to be the most numerous as regards species, Mastigophora and Sarcodina being about the same in number of species. As regards actual numbers of organisms, Flagellates are the most numerous. However, Ciliates persist longer in a culture than any other class of Protozoa. There is daily variation in the numbers of a Protozoön in a given quantity of culture.

Dark, heavy soils containing much humus yielded more kinds of Protozoa than sandy ones. Samples of soil taken relatively near the surface, say six or eight inches down, usually yielded more Protozoa than deeper samples. Cultivated soils yielded more species of Protozoa, especially of Ciliata, than uncultivated ones.

Cysts of Protozoa are very closely attached to soil particles. It has been found, experimentally, that the more finely the soil was pulverised or tilled the more protozoal cysts could be detected.

Owing to partial sterilisation of South African soils by solar heat and drought, the number of Protozoa in a given area of soil seems to be less than in soils from England or the northern United States. The ingestion of Bacteria by soil Protozoa has, so far, not been often observed naturally in South African soils.

"Note on Elasticity of Dwyka Tillite," by J. A. Gilmore (communicated by Dr. J. S. v. d. Lingen).

The preliminary investigation of Dwyka Tillite from Matjesfontein, Cape Province, shows that for an absorption of less than 1/400 gm. per gm. of water Young's modulus decreases by about 12 per cent., whereas for an absorption of order 1/800 gm. per gm. the crushing strength increases by about 50 per cent. and more.

The values of the constants for one specimen are:

Density . . $2{\cdot}73$ gm. per c.c.

Young's modulus by flexure $\begin{cases} \text{dry} . . 5{\cdot}6\times 10^{11} \text{ dynes cm}^{-2}. \\ \text{wet} . . 4{\cdot}9\times 10^{11} \text{ ,, ,,} \end{cases}$

Modulus of rigidity:

dry . . $2{\cdot}5\times 10^{11}$ dynes cm^{-2}

Crushing strength:

dry . . $4{\cdot}0\times 10^{8}$ dynes cm^{-2}

wet . . $7{\cdot}2\times 10^{8}$ dynes cm^{-2}

"On some new South African Parasitic Nematodes," by H. O. Mönnig (communicated by Sir Arnold Theiler).

A collection of parasitic Nematodes from South Africa has been examined and the following new genera and species are described: *Contracaecum praestriatum* n. sp., from *Podiceps capensis*; *Syphaciella capensis* n. gen., n. sp., from *Pterocles bicinctus* and *Pteroclurus namaqua*; *Leptosoma africana* n. sp., from *Paraxerus cepapi*, *Otomys irroratus*, *Mus concha*, *Mus Pretoria*, and *Thrynomys swindernienus*; *Strongylus intermedius* n. sp., from *Varanus* sp., *Impalaia tuberculata* n. gen., n. sp., from *Aepyceros melampus*.

The publication is announced of a description of the whole collection, and the name of *Strongylus* (*Deletrocephalus*) *brachylaimus* v. Linst., 1901, is changed into *Theileriana brachylaima*, while *Filaria subcutanea* v. Linst., 1901, is renamed *Filaria subdermata*.

"Note on the Coevanescence of the Primary Minors of an Axisymmetric Determinant," by Sir Thomas Muir.

"The Serum Constituents responsible for the Sachs-Georgi and the Wassermann Reactions," by T. J. Mackie.

Sera reacting positively in the Sachs-Georgi and Wassermann reactions were fractioned by Liefman's carbon-dioxide method; the active constituent in the flocculation test was the carbonic-acid-soluble fraction; the carbonic-acid-insoluble globulin was inactive and inhibitory. The carbonic-acid-soluble fraction was further fractioned by ammonium sulphate, according to the technique of Browning and Mackie, into its pseudo-globulin and albumin components; it was found that the flocculating action of the serum depended almost entirely on the carbonic-acid-soluble pseudo-globulin; the albumin was inactive but non-inhibitory. In the Wassermann reaction the most active fraction was the carbonic-acid-insoluble globulin; the carbonic-acid-soluble pseudo-globulin was only weakly active and the albumin was inactive. These experiments show that the two serological reactions are independent phenomena, the serum constituent mainly responsible for the Wassermann reaction being inactive and inhibitory in the Sachs-Georgi reaction.

"A Note on the Propagation of Heat in Water," by J. R. Sutton.

This is a brief discussion of some observations of the temperature of the water contained in a brick cistern, 7 feet square and 30 inches deep. There is a double maximum of temperature at the bottom of the cistern. The chief interest of the Note is in the harmonic analysis of the hourly observations. It appears that the heat received by the water is divisible into two parts: one in which the whole body of water is heated nearly simultaneously (chiefly by the sun's rays), the other by virtue of which the surface temperature is propagated downwards as a wave at a rate of about 7 inches an hour.

Contributions to the Discussion on the Distribution of Life in the Southern Hemisphere.

I.—By Professor Andrew Young, M.A., D.Sc.

INTRODUCTORY.

In opening this symposium on the "Distribution of Life in the Southern Hemisphere," I wish to make a few introductory remarks regarding the circumstance which doubtless inspired the proposal to hold such a symposium. The recent appearance of a new theory as to the former extent and position of the continental land-masses has led to a feeling that it might be well to gather together in review the facts of animal and plant distribution which could be regarded as having a relevant bearing on this theory. Hitherto many of the known facts of animal and plant distribution have been explained by means of hypothetical land bridges supposed to have formerly connected the land-masses and to have since sunk beneath the waves. Even large continental masses have sometimes been pictured as having existed for a time, and then, having served their purpose of distributing organisms, have been conveniently allowed to subside into the ocean depths. Thus Lemuria, Gondwanaland, and even the semi-mythical Atlantis have flitted across the vision of naturalists and geologists. Now, more lately, have appeared visions of continents not sinking into the ocean depths, but drifting about horizontally over distances of thousands of miles. Here I would remove a misconception which appears to exist in the minds of some biologists to the effect that this new drifting continent theory is an invention of the geologists and has been based on geological facts—that the geologists are now inviting the biologists to state what facts they have in confirmation of or in refutation of a geological theory. This is not by any means a true conception of the position. Wegener's theory is not based on geology, though he is willing to accept whatever geological assistance may be forthcoming. Previous attempts had been made to found a similar theory on geological facts, but these attempts were largely failures.

In his great work "The Face of the Earth," Suess, the Austrian geologist, devoted much attention to the structure of Asia, and interpreted the structure of that continent chiefly from the horizontal plan of its mountain ranges, and reached the conclusion that the structure was mainly due to horizontal thrust or crustal creep of the continent towards the Pacific and Indian oceans. In 1910 an American, F. B. Taylor, published in the *Bulletin of the Geological Society of America* a lengthy paper entitled "Bearing

of the Tertiary Mountain Belt on the Origin of the Earth's Plan." Taylor in this paper considered the general distribution on the earth of the Tertiary ranges of fold mountains and applied Suess's methods of analysis and interpretation to the other continents, reaching the conclusion of a general creep of land-masses in the northern hemisphere outwards in all directions from Greenland with the Atlantic as a widening rift due to a subsidiary westward creep of the American Continents from Europe and Africa.

These views of Suess and Taylor have never found anything like general acceptance among geologists, as the evidence on which they were founded was felt to be at once of too vague and too restricted a character to form a stable foundation for a hypothesis so tremendous.

In more recent years Professor Alfred Wegener, Director of the German Oceanographic Survey, has published a book called *Die Entstehung der Kontinente und Ozeane*, in which the hypothesis of the migration of continental land-masses is presented in a somewhat more definite and complete form, and based not on geology but on a new foundation of geophysics and oceanography. Professor Wegener is not a geologist, and he is interested in geology as he is interested in botany and zoology, that is, only so far as these sciences may furnish additional support or additional detail to his views. Professor Wegener summarises his view in the May number of *Discovery*, 1922, as "a new view of the nature of the earth's crust, according to which the continents in past ages have drifted horizontally over the surface of the earth and are still in motion at the present time. According to this theory, known as the displacement theory, North and South America were in Mesozoic times continuous with Europe and Africa. They then broke away and moved westwards in Tertiary times, the Andes being forced up by pressure on the forward edge of the drifting continent. Again Antarctica, Australia, and India were formerly in immediate contact with South Africa, India then being the southern end of a long projection from the Asiatic Continent which is now almost entirely crumpled up and forms the Himalayas. The theory asserts that the outermost crust of the earth no longer envelops the whole globe as it once may have done, but has shrunk up in consequence of successive compressions into mountain folds. It is now represented by the continental shelves, which are covered only by shallow seas. The bed of the deep seas is regarded as composed of the material of the underlying deeper layers of the earth, upon which the continental masses float."

"It will be evident that this theory conflicts with the former fundamental views of several sciences, and especially those of geology. For a proper judgment upon it an enormous mass of facts must be collected together from such sciences as geophysics, geology, palaeontology, palaeoclimatology, animal and plant geography, and geodesy."

(Here an enlarged reproduction of a world map, taken from Wegener's book, was exhibited, showing what Wegener believes to have been the distribution of continental land-masses in Carboniferous time.)

During the last year or two there has been going on among geologists a considerable amount of discussion of the views of Wegener and Taylor, but so far I am unaware of any responsible geologist having definitely and whole-heartedly accepted these views. It is recognised by all that there are a number of geological facts that might be regarded as helpful to the Wegener hypothesis. In the Southern Hemisphere the most interesting feature is that the Wegener hypothesis, if adopted, would considerably simplify for geologists the facts of the Permo-Carboniferous glaciation of Australia, India, South Africa, and South America, by bringing the glaciated areas together into one single glaciated region. It is undoubted that if this were done much of the difficulty we have in accounting for the simultaneous glaciation of regions so diverse in latitude, would disappear. Nevertheless the general attitude of geologists towards the Wegener hypothesis as yet seems to be merely one of interested attention. Outside, the facts of Permo-Carboniferous glaciation, the purely geological facts as distinct from palaeontological facts, offer comparatively little that could be regarded either as strongly favourable or as strongly hostile to the hypothesis. The folded ranges of the Sierras of Buenos Aires appear to be of similar age and structure to those of the southern folded belt of the Cape Province, and would be brought into fairly accurate alignment if the South American coast were fitted into the African coast after the manner of Wegener's map of Carboniferous land distribution; but it is, at least, conceivable that this might be accounted for in several other ways. A considerable number of other geological facts are of such a nature that while they might be made to fit the Wegener hypothesis, they could not, even as a cumulative result, be said to form a firm support for it. The allied science of palaeontology probably supplies a larger quota of relevant facts, and in any case, should the time ever come when geologists have to accept the Wegener hypothesis, palaeontology will have to supply the controlling facts from which to date the various stages of the disruption process. Thus it seems likely that all these stages of break-up of the Wegener's southern land-mass must have a post-Cretaceous date, and that the final severance of Patagonia from the Antarctic Graham Land must have a late Tertiary or Quaternary date. The very close and detailed homology of the Tertiary deposits of Graham Land and Patagonia as described by Gannar Andersson forms, in this connection, one of the most relevant pieces of combined geological and palaeontological evidence in the Southern Hemisphere.

II.—By Dr. S. H. Haughton, B.A., D.Sc.

GEOLOGICAL.

In this summary the time-standard used is the European, but the correlations between the events in Europe and those in the Southern Hemisphere are not exact.

Palaeozoic.—Ordovician and Silurian strata are known from New Zealand containing mostly graptolites and brachiopods respectively—the latter comparable with those of Eastern Australia, the former cosmopolitan. Beds of Silurian age are found in Tasmania, but the contained fossils are unlike those from other parts of Australia. Silurian marine fossils occur in Brazil.

Devonian strata with marine fossils of European facies occur in E. Australia. The Bokkeveld Beds of South Africa contain a marine fauna most closely allied to that of the Falkland Islands and South America (Brazil, Argentine, Chile), and having greater affinities with that of E. North America than with W. Europe. It is of middle Devonian age when compared with the former, but has L. Devonian European elements which also occur—but to a less extent—in the South American fauna. Some of the Bokkeveld species are found in the Sahara.

An Upper Devonian fauna is recorded from Brazil; whilst fish-remains from the Beacon Sandstone of Antarctica are described as Upper Devonian.

A marine Carboniferous fauna occurs in both Eastern and Western Australia, containing many species of invertebrates found in Europe, as well as the plants *Lepidodendron*, *Calamites*, etc. In South Africa the plant genera of the Witteberg Beds all occur in Europe. Marine Upper Carboniferous fossils occur in N. Brazil and Bolivia.

Following this came the great Southern glaciation and the subsequent advance of the *Glossopteris* flora. In Australia the boulder-beds are stratified and contain *Gangamopteris*; in S. Brazil marine lamellibranchs and brachiopods are found in the glacial beds.

The beds following the tillite in South Africa contain the aquatic reptile *Mesosaurus*, a crustacean *Pygocephalus* (also found in the Carboniferous of Europe) and the beginning of the *Glossopteris* flora; *Mesosaurus* is also found in Brazil; whilst the marine *Eurydesma* occurs in Australia, India, and S.-W. Africa. Marine and fresh-water or estuarine beds are intercalated in Australia, the latter containing *Glossopteris*; marine Permian fossils occur in New Zealand; but the Permian of South Africa, India, and Brazil are mainly continental in origin, with *Glossopteris* occurring in each area. In addition, South Africa was populated by a varied and vigorous reptilian and amphibian assemblage, with a few fresh-water invertebrates. The

reptiles are chiefly composed of Cotylosaurs and Anomodonts which doubtfully penetrated to India and are represented in N. America, W. Europe, and N. Russia—in the latter area associated with *Glossopteris*. The *Glossopteris* flora is also found in Eastern S. America, the Falkland Islands, and Antarctica.

Mesozoic.—Triassic marine fossils of a Tethyan and circum-pacific character occur in New Zealand, with a small assemblage of land-plants; the latter are part of the richer E. Australian flora which is associated with labyrinthodonts, fish, and fresh-water crustacea and invertebrates. A similar flora occurs in South Africa—as do close allies of the Australian vertebrates—where the beds contain land reptiles, some closely resembling mammals and certainly endemic, others of the Diapsid type similar to those of the European Triassic. Fresh-water invertebrates are sparingly represented. Theropod Dinosaurs, similar to European types, are found also in India and the N.-E. coast of Australia. The Brazilian *Scaphonyx* is closely allied to the South African reptile *Erythrosuchus*.

The Jurassic marine fauna consists of forms related to the Malayan or Himalayan types; and there are plants which are akin to those of Australia. Upper Jurassic marine animals occur on the west of Madagascar and in Tanganyika Territory. Graham Land has a late Jurassic flora which is very closely related to that of England, and was world-wide in distribution. In the vertebrate kingdom the Dinosaur *Megalosaurus* has been recorded from Madagascar and Australia. It also occurs in the Northern Hemisphere; and an Upper Jurassic Dinosaur assemblage is known from the south of Tanganyika Territory.

Lower Cretaceous Theropodous Dinosaurs are known from South Africa, India, Madagascar, and South America; while South America has yielded Upper Cretaceous Theropods and South Africa an Ornithopod. All these are closely related to the rich fauna of the Northern Hemisphere, although the South American Theropods from the Upper Cretaceous are considered endemic genera.

Neocomian marine strata occur in South Africa (Uitenhage), India (Cutch), Tanganyika Territory, Patagonia, Bolivia and Chile, and Argentine, some of the areas yielding land-plants, and the faunas of all are considered to belong to one province. Aptian fossils of similar type occur in Portuguese East Africa and South America. Albian faunas are known from New Zealand, India, Madagascar, Zululand, Angola, Brazil, and Peru. Nine-sixteenths of the New Zealand is of Indo-Pacific character, of which the others partake. The Angola fauna, however, is only connected with the Zululand fauna by way of East Africa, Egypt, and Tunis—having a somewhat Mediterranean aspect. The Senonian marine fauna is widespread. It occurs in New Zealand, Chile, Peru, South Patagonia, Seymour, and

Snow Hill Islands, Pondoland, Zululand, Mozambique, Madagascar, India, and Angola—although, as in Albian times, the last-named fauna is not closely comparable with that from other southern areas. The New Zealand fauna has many affinities with that of South America and the Antarctic Islands; and the other regions also lie within the same marine province. This was a period of marine transgression. In addition, Queensland has yielded Neocomian rocks of fresh-water origin with plants, and Upper Cretaceous rocks with land plants and a marine fauna, of which only one species of mollusc is found in the New Zealand fauna. An Upper Cretaceous flora from the Argentine has close similarity with the Dakota flora of North America.

Tertiary.—Consideration of the Tertiary will be confined to land-remains. Little is known of these in New Zealand save for a few plants. In Australia such Tertiary mammals as are known are marsupials; whilst, according to Ettingshausen, the flora is of a mixed character, comprising European, Arctic, and North American characters with a somewhat feeble representation of present-day characteristics.

In South Africa nothing is known of the flora, and but little of the vertebrates. The latter seem to be allied to living African forms or to European Tertiary species; one species has been compared with a South American fossil.

South America developed a rich, varied, and distinctive fauna; the origin of which Loomis traces to North America, with which South America had land connection in the Upper Cretaceous and early Eocene times. Isolation then took place with consequent specialisation. The floras of Chile, Colombia, Ecuador, and Peru were a development of a Holarctic flora which invaded the area in Upper Cretaceous times. The Tertiary flora of Seymour Island contains elements suggestive of the S. Brazil and S. Chilian and Patagonian floras of to-day, including species of *Fagus* and *Nothofagus* like those of Chile, Patagonia, Australia, and New Zealand.

III.—By Mr. K. H. Barnard, M.A., F.L.S.

ZOOLOGICAL.

The distribution of Peripatus, Acarid Mollusca, fresh-water Decapod Crustacea, and the Isopod Crustaceans *Deto* and *Phreatoicus* was discussed and illustrated with maps. It was shown that, so far from the zoologist being able to help formulate an explanation of the palaeogeographical history of the continents, he was really entirely dependent on the geophysicists and geologists; and that in some cases the facts of present-day distribution were capable of being explained in terms of either

a far-reaching equatorial Gondwanaland or a compact polar Gondwanaland. Examples were given which apparently were more reasonably explained in terms of the latter hypothesis. The effects of assuming a polar Gondwanaland on "primitive forms at the periphery of the continents," and the difficulties of deciding between really primitive characters and later-acquired simplifications of structure, were also discussed.

The distribution of the species of Peripatus when plotted on a polar projection map is remarkable, in that the *Peripatopsidae* occupy a central position while the *Peripatidae* are peripheral.

There is little to choose, zoologically, between Watson's (1915) theory of the dispersal of Acarid snails from S.-E. Asia and Hedley's (1899) theory of their origin in Antarctica. Whichever explanation of the palaeogeographical changes in the shapes and positions of the continents is adopted by geologists as most reasonable, must be used as a basis by zoologists.

The Decapod Crustacea are in a similar category. If the ancestors of the fresh-water Crayfishes originated in an arm of the Indo-Pacific which gradually penetrated into the polar Gondwanaland in pre-Jurassic times, the same results will follow as those sketched out by Ortmann (1902) for post-Jurassic times.

The Isopod Crustacean *Deto* was given as an example of wide and discontinuous sub-antarctic distribution, and of the useful results which might be expected to follow from a study of its habits and of the possible causes of extinction in intervening regions.

In all the above examples palaeontological evidence is lacking, and the facts of present-day distribution are of little help to the geologist. But where there is palaeontological evidence, the zoologist may be of use.

A case in point is the Isopod *Phreatoicus*, and its importance can scarcely be over-estimated. At the present day *Phreatoicus* is found in Australia, Tasmania, New Zealand, and South Africa. There is the closest possible likeness between some of the Australian forms and the Cape species. In Australia there is also a fossil species of Triassic age, which provides an almost positive proof that this animal was not only palaegenic, but also austrogenic, and that the regions where it exists to-day were once in the very closest relationship to one another.

IV.—By Professor H. B. Fantham, M.A., D.Sc.

ANIMAL PARASITES.

The occurrence and distribution of some of the chief human and animal parasites in the Southern Hemisphere, some of them peculiar thereto, were considered. It was pointed out that such a consideration was of importance,

though it might not directly aid in the elucidation of the former distribution of host animals, yet the action of parasites had doubtless been a factor in bringing about extinction of certain hosts in the past.

The three known species of human trypanosomes all occur in the Southern Hemisphere. *Trypanosoma gambiense* and *T. rhodesiense* are the causal agents of sleeping-sickness in man, and are spread by tse-tse flies, belonging to the genus *Glossina*, which is confined to the Ethiopian region. The third human trypanosome, *T. cruzi*, occurs in Brazil and is spread by a large bug, *Triatoma megista*. Among domestic animals in the Southern Hemisphere, trypanosomes occur, such as cause nagana in cattle in Zululand, and mal de caderas in horses and dogs in South America. The big game of Zululand form reservoirs or tolerant hosts of *T. brucei*. It is of unfortunate interest that the majority of disease-producing trypanosomes of the world occur in the south.

Ticks and tick-borne diseases are very prevalent in the Southern Hemisphere. East-coast fever, due to *Theileria parva*, is tick-borne, and is chiefly confined to Africa.

Among fluke diseases, urinary bilharziasis in man seems to be endemic in Africa and largely confined thereto.

Among round-worms, most of the Filariidae, found in the blood and lymph of men and domestic animals, occur especially in Africa. Most of the Filariid parasites of men are largely confined to Africa, though some of them have been carried to Central and South America, probably with negro slaves. Another Filaria, *Onchocerca gibsoni*, found in cattle in Queensland, is responsible for " wormy nodules " in briskets. Filarial worms are certainly relatively numerous in the Southern Hemisphere.

To draw conclusions from parasitism as to the distribution of life in former times involves too many hypotheses, among others the origin of digenetic parasites, the question of definitive hosts and tolerance of host and parasite. Only the present-day distribution of certain parasites in the Southern Hemisphere was attempted.

V.—By Professor J. W. Bews, M.A., D.Sc.

BOTANICAL.

Professor Bews indicated the lines along which further study of the problems of distribution of life in the Southern Hemisphere could most profitably be undertaken. In the testing of Wegener's theory he recommended separate consideration of two elements (*a*) the tropical-sub-tropical and (*b*) the temperate or mountain. He referred to Willis' view, that endemics are on the whole recent, as necessitating a reconsideration of the

facts of distribution: and advocated also what may be called the standpoint of ecological evolution—the adaptation of vegetation to environments of which some have remained relatively constant through vast periods of geological time, while others, especially the drier habitats, are probably more subject to fluctuating changes or complete transformation. Many ancient types of flowering plants are found in habitats of the stable type. He referred to his recent work (*e.g.*, *Annals of Botany*, 1922) in which a beginning is made in the intensive study of migration within South Africa.

VI.—By Professor R. H. Compton, M.A.

BOTANICAL.

The perfection of the means of dispersal of plants renders many of the facts as to the modern distribution of ancient groups (Cryptogams) almost valueless as an indicator of former land connections. Recent phyla only, especially the Angiosperms, can be relied upon. The Angiosperms arose during Cretaceous times, and most modern families are represented in the Eocene. The Wegener hypothesis, according to Du Toit, contemplates the wide disruption of South Africa and Australia in the Jurassic; but South America was only separated from South Africa by a very narrow strait at the end of the Cretaceous. Nevertheless the floristic resemblances between temperate South Africa and South America are much less conspicuous than between temperate South Africa and Australia. We must therefore look elsewhere than to the Wegener theory for an explanation of Angiosperm distribution in the South Temperate Zone.

The floristic relationships between Australia, South Africa, and South America are best explained as being due to lateral migration, perhaps in the warmer Miocene, from a comprehensive tropical belt of vegetation. This tropical reservoir contained most of the great Angiosperm families and stretched around the whole world except the Pacific. (Strong resemblances exist, between the tropical African and tropical American floras, which may point to a continuity of land surface between them.) The South Temperate floras, therefore, are linked through the tropics (except for South America and New Zealand, which certainly seem, from floristic and other evidence, to have been connected by land *via* Antarctica in the Miocene). The modern distribution of the Rutaceae, for example, is an excellent instance of the process of migration southwards (as well as northwards) from this tropical reservoir. A tentative explanation of the distribution of *Helichrysum*, Proteaceae, Restionaceae, etc., may be given on the same lines. Angiosperm distribution in the South Temperate sub-continents was mainly subsequent to the disruption envisaged by the Wegener theory.

VII.—By Dr. A. L. du Toit, B.A., D.Sc.

PALAEOBOTANY.

While a certain amount can be deduced concerning the distribution of plant life in the Southern Hemisphere during the past, it happens that in South Africa there are serious gaps in the geological record covering the whole of the Jurassic, and that the later Cretaceous and unfortunately, too, the Tertiary have so far yielded no palaeobotanical material.

Proceeding backwards into the Carboniferous we find that *Gangamopteris*, the type genus of the lowest zones of the Gondwana System in the Southern Hemisphere, makes its appearance beneath the glacial "tillite" at Vereeniging. Since this is apparently upon a lower horizon than anywhere else on the globe, the presumption naturally follows that South Africa could well have been the centre of evolution of this genus, and if so, probably of other members as well of the peculiar "Southern or Glossopteris Flora."

It is suggestive finding at a later date in the Middle Ecca "Coal Measures" (Lower Permian) such typical Carboniferous genera as *Sigillaria*, *Bothrodendron*, and *Psygmophyllum* (subsequently *Sphenophyllum*), these being characteristic members of the "Northern Flora." They can be regarded as invaders from the South American section of Gondwanaland, into which it is known that this flora had spread at an earlier date, perhaps from North America. Conspicuous, however, is the absence, so far as we are aware, of the curious form *Psaronius*, well known from the Permian strata of north-western Brazil.

These assumedly exotic types disappeared from South Africa later on, and during the later Permian and the early Triassic, the local flora became reduced extraordinarily throughout Gondwanaland, but especially in the African section thereof. This would point to the isolation of the southern land-mass from the rest of the world; the sporadic occurrence of *Glossopteris* in Russia is as yet hardly explicable.

During the Upper Triassic an abundance of new forms and families made their appearance, of which certain are characteristic of India, Indo-China, and Australia, and presumably had been evolved in Gondwanaland; but there are, in addition, quite a high proportion which have their closest allies in Europe. Amongst them are certain peculiar genera of marked palaeozoic affinities, such as *Callipterodium* and *Odontopteris* of the Pteridophytes and the medullosean *Rhexoxylon*; these can most reasonably be viewed as relics pushed down into this corner of the continent by the invading flora with its northern elements. Evolution during the progress of this southward migration is, however, indicated by the species represented in South Africa being generally "Gondwana," while the Cycadophyta are all "African" and possibly indigenous.

A stratigraphical break covers the whole of the Jurassic, but at the very close of that epoch a flora appears of which the filicalean genera and species are typically European, but the Cycadophyta show, like those of an earlier date, a local facies, the species being possibly endemic.

Although the bulk of the southern half of the African continent was land from the beginning of the Jurassic, a younger Cretaceous flora has not yet been discovered in this quarter of the globe, and the record is silent over that important period embracing the rise of the Angiosperms; the same is the case in the Tertiary.

Lamentably, therefore, botanists are unable to do more than make guesses at the probable origin of the present flora, there being no fossil or even sub-fossil representatives with which to institute comparisons. Hence search is greatly to be desired among the late Tertiary sands, clays, and lignites.

VIII.—By Dr. L. Péringuey, D.Sc.

THE ENTOMOLOGICAL SIDE OF WEGENER'S THEORY.

To one who is not a systematic entomologist and who throws a cursory glance at a collection of Insects of all Orders from Australia, South America, and Africa standing side by side, the extreme difference between the three will be striking at first sight. To the systematist who is guided by the details of structure rather than by the morphological appearance, the connection or otherwise between the individuals of the three series becomes more defined. But he soon realises that the difference is very great. If, moreover, he scans groups from other parts of the world he must come to the conclusion that there is more affinity with African and Palaearctic species, and still more with those of many Indian Orders. That is to say, there is a more regular morphological aspect, and closer relationship in genera and species. So that if it is supposed that in Mesozoic times North and South America were contiñuous with Europe and Africa, and also with Australia, Antarctica, and part of India, but from these times this one continent split in parts which moved away from each other, the theory would receive confirmation if it were found that all Orders or Groups, if not Families, represented in these newly freed Continents are the same. The phylum then established would continue to develop its branches on either side of the line of separation. The plasticity of the organism already acquired would increase in a general way, the divergence would become greater as time went on, and the differences would increase in the same ratio, the result of these gradual divergences being the morphological difference noticed in the zonal faunas above mentioned. But these conditions can be equally well explained by the former theories of a sub-

merged equatorial continent, or land connections, and I fear that, as far as Entomology goes, Wegener's theory will not receive from it an important support. The key should be found in Palaeo-Entomology, but unfortunately this branch of palaeontology has not hitherto given us indications of a conclusive nature, in spite of the comparatively immense development of the Arthropod Phylum, for it is not to be admitted that because most of the early developments recorded to date are from the Upper Carboniferous and Permian there are not other forms that have escaped detection.

For my purpose, however, I shall put aside those Orders which, provided with wings, would be better adapted for wide distribution, and restrict myself to the Coleoptera or beetles. Although many, perhaps most, are winged, they are nevertheless unable to cover naturally large areas by flight. But I may at the same time mention that the earliest insects known, Blattoidea or Cockroaches, mostly winged even at this early epoch, *i.e.* Upper Carboniferous, include 85 per cent. of the insects known from this formation, while in the Lias they fall to 6 per cent. only. Yet they are hardly different from the survivors of the present day, and as in the case of *Phreatoicus*, mentioned by Mr. Barnard in this discussion, the only possible explanation is to credit these organisms with a greater amount of vitality, obtained possibly at the expense of plasticity which has enabled them to retain their present form. To me, this is the only possible explanation of the rare survivals of ancient forms, whereas the immense majority have diverged more and more from the parent stock.

But to come back to the Coleoptera.

They appear in the Trias few in number: 19; in the Jurassic we have 369. In the Cretaceous, 10 in the Lower, 14 in the Upper; but in the Tertiary their great development is apparent. Eocene, 33; Oligocene, 1084; Miocene, 788; Pliocene, 7; Pleistocene, 373, etc.

Among the earliest we find, in Jurassic times, predaceous species: Carabids; Hydroporous Staphylinid, also Curculionidae, which are phytophagons or plant-feeding insects. In the Lias, the recorded Coleopterous genera include 37 per cent. of the known Insect fauna of this formation; more numerous are the predaceous Carabid and Hydrophilid; at that time appear the Elaterid, Buprestid, etc., living at the expense of vegetation. In the Lower and Upper Cretaceous we find Carabid, Silphid, Tenebrionid, Cerambycid; Chrysomelid, Curculionid. In the Tertiary or Caenozoic are recorded: Eocene, 33; Oligocene, 1084; Miocene, 788; Pliocene, 7; Pleistocene, 373 species. It is in the Oligocene Division that these ancient forbears have left most traces. The following Orders predominate: Curculionidae, with 234; Staphylinoidea, 148; Phytophaga, 133; Carabidae, 85 species, etc. But this extremely high proportion of predaceous beetles entails perforce the evidence of a very much larger proportion of non-

predaceous ones, the evidence of which has not yet been revealed. Now, we find in the Jurassic primary in the full sense of the word evidence of a Carabus. It thus becomes interesting to look for the present distribution of the descendants, all, or nearly all, now apterous, *i.e.* wingless. The species are extremely numerous in Europe, and they are found also in Northern America, in Western Asia, in Boreal Asia, in the Himalayas, China, and in Algeria and the Canary Islands, but seven kinds are recorded from Chile, some at great altitudes. Unknown south of the Sahara, the genus, very little modified, occurs on the high levels of Abyssinian mountain ranges, and it has been found on Kilimandjaro 1560 m. and Mount Gurnie 1000–1600 m. No other species is known to occur southward, but in St. Helena there is a very striking species. Is it not more likely that this ancient genus marks the survivance on now isolated spots at great altitudes of a very ancient form, as Carabus is now proved to be, than to assume the connection with St. Helena, and the opposite side of the curve of South America round the extremity of South Africa where the genus does not exist any more than it does in Australia, where its vitality should have ensured its survival? But even the phyllogeny of Carabus can go counter to, or support Wegener's theory, because the nearest ally to Carabus is the genus Calosoma, which, however, unlike Carabus, is winged. There are three species in South Africa, three in Australia, none in Chile proper (unless the Galapagos Island be taken as part of Chile), and one in Patagonia. This distribution may seem to support the unity of the continents alleged by Wegener, whereas that of Carabus militates against it. But in spite of this discordance, I opine that the present distribution of animals and plants will not, on the whole, support or militate against Wegener's theory. The Palaeontology of Insects is too rudimentary as yet. But the fact remains that the difference between the entomological fauna of these continents is extreme. It may be stated that very few genera in the one are represented in the other, except among powerful fliers or a few very ancient forms. As far as South Africa is concerned, we have along the coast in what is called the Strand feld partly linked with the Karroo a faunule purely South African. None of the endemic forms of the different Orders forming that faunule occur in South America or in Australia, or for the matter of that in India. But in Australia there is a group of large Curculionidae so much resembling another purely South African group that, at first sight, the two might be taken to represent the same stock in two now widely separated continents. But the similarity is superficial. It is probably a case of convergence, a more powerful factor, in assumed resemblance than is usually credited. Yet, in this case, it must not be forgotten that Curculionidae spring from an extremely ancient stock, and that Hipporrhinus (S. Africa) and Leptops (Australian), etc., may not, after all, be a case of convergence,

but one of slight modification, and thus from all Orders of Insects could examples for, and examples against, the theory under discussion be given *ad infinitum*. The number of insects is credibly considered to equal that of nine-tenths of the animal world, and yet we know little after all of their phylum. But it seems to me that their dispersion is as readily accounted for by the geological theories now obtaining, as by that of the disruption from Tertiary times of one continent into four as claimed, if it is so claimed, by Professor Wegener.

IX.—By Mr. J. Hewitt, B.A.

A NOTE ON THE DISTRIBUTION OF CERTAIN TOADS, CONSIDERED IN REFERENCE TO THEIR FORMER LINES OF DISPERSAL.

Of late years, ingenious attempts have been made to prove that all the main groups of animals have had their centres of dispersal, and even also their origins, in the Holarctic region. The Antarctic and Southern lands are represented as "unfavourably situated for the evolution and dispersal of dominant races and contributing but little to the cosmopolitan faunas of the emergent phase." The leading exponent of this view, Dr. W. D. Matthew, is certainly able to present a considerable amount of evidence in support of the principle in so far as the Mammals are concerned, but his proposed extension of the theory to explain the present distribution of toads is not well fitted to the facts. Nor, indeed, is the mammalian evidence so convincing as some advocates would wish, since, in order to explain the occurrence of Hystricomorph rodents in South America, he is obliged to assume that floating rafts have carried them across the Atlantic Ocean from Africa to America; thus Dr. Matthew avoids the necessity for a Gondwanaland hypothesis. Traversing, as it does, the whole range of the animal kingdom, the problem requires detailed treatment of each small section before any general principle should be formulated. In the following notes I shall restrict consideration to the group of vertebrates I know best.

Distribution of the Cystignathidae.

In Dr. Matthew's paper there is a figure (p. 296) stated to represent the distribution of the three families Cystignathidae (Southern Hemisphere), Discoglossidae (both north and south), and Pelobatidae (Northern Hemisphere). He tells us that "these three families represent evidently three successive dispersals" from the north. Now, his map is actually incorrect

as regards both Cystignathidae and Discoglossidae. If he had not omitted to show the latter family in New Zealand, the three successive dispersals would not have seemed so plausible. Moreover, there is no reason whatever for supposing that these three families have the genetic relationship implied in Matthew's suggestion—that is, the Cystignathidae as primitive members of an original stock, driven southwards by the more advanced Discoglossids, and these latter displaced by the still more advanced and recent Pelobatids. The three families may have originated and dispersed contemporaneously, or even in the reverse order to that indicated above. From point of view of structure, according to the most recent scheme, that of G. K. Noble, the Cystignathidae represent not the most primitive family, but the most specialised of the three, and the Discoglossidae are most primitive. Now, according to the principle mentioned at the commencement of this paper, we should expect to find in the Southern continents a great preponderance of the most primitive families, whilst the most advanced families should be located in the Northern Hemisphere. But, actually, such is not the case. South America and Africa, which should have archaic faunas, are completely devoid of the primitive Discoglossids and Pelobatids: the old fauna is only represented by the Pipidae toads. Moreover, on the continent of Australia not one of these families occur, but New Zealand shares the Discoglossidae with the Palaearctic region.

It is certainly very difficult to explain such data in terms of a northern centre of dispersal. The occurrence of the two primitive families in the Holarctic region forbids our presuming the former occurrence of the more progressive Cystignathidae there.

The distribution of the Cystignathidae is peculiarly southern. Both in South America and in the Australian-Papuan region they are the principal elements of the Anuran fauna. In addition there is a single African genus, Heleophryne, which is only known from the Cape and Natal. Its relationships are not very clear, for, in some respects, it approaches the Australian genera and in others the South American. There is no evidence that any of the numerous genera composing this family have previously enjoyed an extensive distribution: each one is confined to a single geographical region, and thus it seems likely that the generic differentiation has taken place in the Southern Hemisphere.

I have previously expressed the opinion that the known facts are best explained on the assumption of former land connections between Australia, South Africa, and South America through Antarctica: but Mr. G. K. Noble now assures us that there is no need for the Antarctic continent, nor for mid-Atlantic land bridges—"if we assume a (north) polar origin for the Pipidae, Hylidae, and Cystignathidae (Leptodactylidae he calls them), we

escape the necessity for building any land-bridge." Thus, we have to assume that there was once a Cystignathid fauna throughout the Northern Hemisphere and throughout Africa, which fauna has completely disappeared except for the Southern species. There is no actual evidence in favour of this: it is offered merely as a simpler assumption than that of the objectionable land-bridges.

Now, from the work of Mr. Noble and several earlier authorities we realise that the family Cystignathidae is not really separable from the Bufonidae: these latter seem to be merely toothless Cystignathids. The toothed Cystignathid genera are to be regarded as primitive, and the various Bufonid genera as derived therefrom. The position may now be stated as follows (excluding from consideration the genus Bufo, which is a recent and hardy cosmopolitan, except in Australia): —

(*a*) There are 30 genera, some toothed and others toothless, in South America, and 2 additional genera restricted to Central America, but except for one or two stragglers in Northern Mexico and Florida, none of these extend their range beyond the neotropics, and of those genera which occur north of the isthmus, "probably the majority have pushed their way northwards since the Panama connection" (G. K. Noble).

(*b*) There are 12 toothed genera and 3 toothless in Australia: 2 of the former and 1 of the latter occur in Tasmania: the Indo-Oriental region has no toothed genera whatever, but has a number of toothless ones.

(*c*) Africa has a single peculiar toothed genus in the extreme South and several toothless ones in the tropics, which latter, however, are not peculiar, but are represented also in the Oriental region and Australia: one of them (Pseudophryne) is derived directly from an Australian toothed genus, and the other is hardly separable from it, according to Noble.

There is nothing to indicate that in their headquarters (Australia and South America) the toothless forms are relentlessly pushing the more primitive toothed genera to the least hospitable regions: and nothing to indicate that they represent two successive waves of dispersal from the north. I interpret the facts as pointing to Australia as the centre of dispersal for all the old world genera of Cystignathidae and Bufonidae—excluding Bufo as above mentioned, and perhaps also Heleophryne. The toothless Bufonids now living in tropical Africa and the Oriental region have migrated there from Australia: thus they do not provide a missing link in the hypothetical world-wide distribution of the Cystignathidae.

A consistent theory should embrace also all other members of the sub-order Procoela. Such are the families Hylidae and Brachycephalidae. Concerning the latter, nothing more need be said than that it is confined to the Neotropical region, where, no doubt, it originated, as Noble suggests.

The Hylidae, from structural considerations, have to be regarded as derivatives of the Cystignathidae. The main features of their distribution are as follows: Abundant in the South American and Australian regions; completely absent from the Indo-Oriental region and from tropical and South Africa: except for the regions just mentioned, the genus Hyla itself is almost world-wide.

This is exactly as we should expect of a moderately recent group on our theory of a centre of dispersal for the Procoela in or through Antarctica. We may presume that the Hylidae originated in South America at a time when there was still a connection with Australia through Antarctica, but the connection with South Africa which had previously made possible the introduction of Heleophryne, had already broken down.

LITERATURE.

"Climate and Evolution," by W. D. Matthew, in *Annals of the New York Academy of Sciences*, Vol. XXIV, pp. 171–318, 1915.

"The Phylogeny of the Salientia," by G. K. Noble, in *Bulletin of the American Museum of Natural History*, 1922.

An Ordinary Meeting was held on Wednesday, October 18, 1922, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

Business:—

The Minutes of the previous Meeting were confirmed.

Mr. J. A. Gilmore, B.Sc., proposed by Dr. J. Steph. v. d. Lingen seconded by the Hon. General Secretary, was elected to Membership.

The Hon. General Secretary announced the Council's recommendation for Officers and Council for 1923 as follows:—

Members of Council: Mr. K. H. Barnard, Dr. J. W. Bews, Dr. L. Crawford, Dr. J. P. Dalton, Dr. J. D. F. Gilchrist, Dr. S. H. Haughton, Dr. W. A. Jolly, Dr. J. S. v. d. Lingen, Dr. T. J. Mackie, Dr. A. Ogg, Dr. A. W. Rogers, and Dr. S. Schönland.

Officers: President, Dr. A. OGG; Hon. Treasurer, Dr. L. CRAWFORD; Hon. General Secretary, Dr. W. A. JOLLY.

Dr. J. STEPH. V. D. LINGEN was received as a Fellow.

The following resolutions were proposed by Dr. L. PÉRINGUEY and adopted:—

(1) That the Council should recommend to Government that the name "Luderitzbucht" should be dropped and the name "Angra Pequena," which occurs in the Atlas of 1668, should be restored.

(2) That the use of the name "South-West Africa" should be discontinued and the name "Damaraland" substituted for it.

(3) That Council should consider the desirability of holding a Conversazione once a year.

Discussion:—

The discussion on the Distribution of Life in the Southern Hemisphere, begun at the last Meeting, was continued.

Exhibit of Charophyta:—

Miss STEPHENS exhibited several specimens of South African Charophyta, and asked for the help of members in collecting specimens of this group of plants. Very little work has been done hitherto on the South African Charophyta, which are proving most fruitful as regards new species and interesting forms.

The following communications were read:—

"The Cones, Spores, and Gametophytes of Selaginella Pumila," by Miss A. V. DUTHIE.

"South African Larval Trematodes and the Intermediary Hosts," by F. G. CAWSTON.

The paper contains a list of the commoner species of fresh-water molluscs that are found in certain rivers of South Africa, as well as some lagoon inhabitants which are occasionally found in quite fresh water. The paper also shows which are the commoner larval trematodes of these localities.

"Colour and Chemical Constitution. Part XVIII.: Colourless Substances in Concentrated Sulphuric Acid Solution (Halochromy)," by JAMES MOIR.

In this solvent even very simple substances exhibit colour. Observations on 25 of these, mostly colourless *per se*, are recorded, and a scheme for calculating the colour from the chemical constitution is put forward.

"African Alcyonaria, with a Statement of some of the Problems of their Dispersal," by J. STUART THOMSON.

Anniversary Meeting.

The Anniversary Meeting of the Society was held on Wednesday, March 21, 1923, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. J. D. F. Gilchrist, was in the Chair.

The Report of the Hon. General Secretary was submitted and adopted.

The Report of the Hon. Treasurer was submitted and adopted.

The following were elected Members of Council for the year 1923 :—

Mr. K. H. Bernard, Dr. J. W. Bews, Dr. J. P. Dalton, Dr. J. D. F. Gilchrist, Dr. S. H. Haughton, Dr. J. S. v. d. Lingen, Dr. T. J. Mackie, Dr. A. W. Rogers, and Dr. S. Schönland.

Dr. A. Ogg was elected President ; Dr. L. Crawford, Hon. Treasurer ; and Dr. W. A. Jolly, Hon. General Secretary.

Ordinary Meeting.

An Ordinary Meeting was held.

The President, Dr. A. Ogg, was in the Chair.

The Minutes of the last Ordinary Meeting were confirmed.

The following were nominated for Membership :—

Mr. H. A. Storey, proposed by Dr. F. G. Cawston, seconded by Professor R. H. Compton ; Dr. A. Reith Fraser, M.D., proposed by Professor T. J. Mackie, seconded by the Hon. General Secretary ; Mr. D. J. Malan, B.Sc., proposed by Dr. D. E. Malan, seconded by Professor L. Crawford ; and Dr. W. P. Mulligan, O.B.E., M.B., Ch.B., D.P.H., proposed by Professor T. J. Mackie, seconded by Dr. J. S. v. d. Lingen.

The following communications were made :—

"On the Passage of Cathode Rays through Matter," by Basil T. Schönland.

The author examined the absorption, reflection, and secondary emission, involved in the passage of fast cathode rays through thin foils of various metals, and their variation with the velocity of the rays. Accurate measurements were possible up to ·4 of the velocity of light.

The results show that Lenard's Law is only an approximation, and that these rays behave in a precisely similar manner to the β rays as examined by R. W. Varder.

The existence of a "range" for these particles appears to be established, two independent methods of measuring it agreeing very satisfactorily. The values obtained and their variation with velocity are in satisfactory agreement with the theory of absorption due to Bohr.

"Holtzhuisbaaken Spring, Cradock," by THOMAS STEWART.

The spring discussed is a typical Karroo spring. Measurements of the flow have been taken over a period of 38 years. The rainfall of a particular season is found to be reflected in the flow of the spring, but is not necessarily proportional to it. Regard must be had as well to the rainfalls of previous seasons and the "tail" of the flow produced by them. There has been a striking diminution both in the rainfall and in the flow of the spring during the last two 10-year periods as compared with the first two 10-year periods, but during the twenty years ending 1921 there has been no further diminution either in the rainfall or in the average flow of the spring.

"Two New Species of Nematodes from the Zebra," by GERTRUD THEILER, B.A., Ph.D. (communicated by Sir ARNOLD THEILER).

A description is given of two new Nematode parasites of the zebra: *Cylindropharynx intermedia*, inhabiting the pelvic flexure and dorsal colon of the host, of which it is one of the commonest parasites; and *Habronema zebrae*, occurring in fairly large numbers in the stomach. These specimens were taken from three zebras shot at Bossieshoek, Rustenburg, and formed part of a large collection of equine intestinal Nematodes made at Onderstepoort and of which a description is announced.

"Note on Zeipel's Condensation-Theorem and Related Results," by Sir THOMAS MUIR.

Both Zeipel's papers on determinants are now over fifty years old, and though they have not been entirely neglected, it cannot be said that they have received sufficient and sufficiently discriminating attention. The text-books of determinants—which, of course, ought to keep a watchful eye on any attractive facet of their subject, have in particular been strangely remiss. In this paper attention is drawn to one or two of the basic results of Zeipel's first paper, and to a number of deductions that cluster somewhat picturesquely round them.

REPORT OF THE HON. GENERAL SECRETARY FOR 1922.

Eight Ordinary Meetings, the Annual Meeting, and the Anniversary Meeting were held during the year, and the following papers were read:—

1. "The Soils of the Hartebeestpoort Irrigation Area (Pretoria and Rustenburg Districts)," by B. DE C. MARCHAND and B. J. SMIT (communicated by Dr. C. F. JURITZ).

2. "The Trend of Radio-Development," by H. E. Penrose.

3. "A Study in Charcoal," by W. S. H. Cleghorne.

4. "Some Notes on the Differentiation of Closely-allied Schistosomes," by F. G. Cawston.

5. "Fungi of the Stellenbosch District and Immediate Vicinity," by P. A. v. d. Bijl.

6. "Note on the Bronze-brass Industry among South African Aborigines," by L. Péringuey.

7. "On a Minor Improvement in the Multi-range Potentiometer," by W. H. Logeman.

8. "The Control of Evaporation by the Temperature of the Air," by J. R. Sutton.

9. "Note on a Determinant with Factors like those of the Difference-product," by Sir Thomas Muir.

10. "Colour and Chemical Constitution. Part XVII.: The Azo Dyes and other Monocyclic Colours," by James Moir.

11. "On some Upper Beaufort Therapsida," by S. H. Haughton.

12. "Observations on the Protective Action of Normal Serum in Experimental Infection with Bacillus Diphtheriae," by T. J. Mackie.

13. "Note on the Electrogram of the Frog's Gastrocnemius Reflexly Excited," by W. A. Jolly.

14. "Note on a Cystoscopic Irradiator and an Ultra-violet Light Illuminator," by J. S. v. d. Lingen.

15. "Note on Maps Illustrating the Zoological Aspects of Wegener's Disruption Hypothesis," by K. H. Barnard.

16. "Note on an easily Constructed Automatic Toepler Vacuum Pump," by W. H. Logeman.

17. "Note on a Capillary Electrometer and its Application to Atmospheric Electricity," by B. F. J. Schönland.

18. "The Rhythm of Discharge of the Spinal Centres in the Frog," by W. A. Jolly.

19. "On the Mathematics of the Homogeneous Balanced Action," by John P. Dalton.

20. "Communications on the Distribution of Life in the Southern Hemisphere," by S. H. Haughton, A. Young, K. H. Barnard, J. D. F. Gilchrist, H. B. Fantham, J. W. Bews, R. H. Compton, D. Thoday, A. L. du Toit, L. Péringuey, and J. Hewitt.

21. "Some Protozoa found in Soils in South Africa," by H. B. Fantham.

22. "Note on Elasticity of Dwyka Tillite," by J. A. Gilmore (communicated by Dr. J. S. v. d. Lingen).

23. "On some new South African Parasitic Nematodes," by H. O. Mönnig (communicated by Sir Arnold Theiler).

24. "Note on the coevanescence of the Primary Minors of an Axisymmetric Determinant," by Sir THOMAS MUIR.

25. "The Serum Constituents Responsible for the Sachs-Georgi and the Wassermann Reaction," by T. J. MACKIE.

26. "A Note on the Propagation of Heat in Water," by J. R. SUTTON.

27. "The Cones, Spores, and Gametophytes of Selaginella Pumila," by Miss A. V. DUTHIE.

28. "South African Larval Trematodes and their Intermediary Hosts," by F. G. CAWSTON.

29. "Colour and Chemical Constitution. Part XVIII.: Colourless Substances in Concentrated Sulphuric Solution (Halochromy)," by JAMES MOIR.

30. "African Alcyonaria, with a Statement of some of the Problems of their Dispersal," by J. STUART THOMSON.

31. "Note on a Property of Bigradient Arrays connected with Sylvester's Dialytic Eliminant," by Sir THOMAS MUIR.

Vol. X, Parts 2, 3, and 4, of the Society's Transactions have been issued during the year.

The following have been elected Fellows in 1922: Hon. Sir EBENEZER JOHN BUCHANAN; ERNEST JOHN HAMLIN, D.Sc.; JAN STEPHANUS VAN DER LINGEN, B.A., Ph.D.

The number of Honorary Fellows is 3; Fellows, 56; Members, 164.

The deaths since the 1922 Anniversary Meeting of Sir W. BISSET BERRY, SYDNEY COWPER, C.M.G., J. DODT, Members, are recorded with regret.

G. A. H. BEDFORD, H. G. DENHAM, W. JOHNSTON, J. LYLE, D. T. MITCHELL, Members, are resigning from the end of the year. Two Members are being struck off the roll from the end of the year.

REVENUE AND EXPENDITURE ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1922.

Revenue.

	£ s. d.	£ s. d.
To Subscriptions for 1922 :		
Subscriptions collected for 1920	13 0 0	
" " 1921, *less* D. J. Wood's, paid twice	48 19 0	
Subscriptions collected for 1922	265 9 0	
" " 1923	6 14 0	
" " 1924	2 0 0	
" collected in 1921 for 1922	4 13 0	
Outstanding Subscriptions at December 31, 1922	64 0 0	
	404 15 0	
Less : Outstanding Subscriptions at December 31, 1921, £75, 19s. ; and Subscriptions collected in 1922 for 1923 and 1924, £8, 14s.	84 13 0	
		320 2 0
" Entrance Fees		6 0 0
" Government Grant, 1922–23		300 0 0
" Interest received :		
On Fixed Deposit, £500, at Standard Bank for 1 year at 5½ per cent... ..	27 10 0	
On £400 Union of South Africa 5 per cent. Stock	20 0 0	
On money in Savings Bank Department of Standard Bank	2 15 6	
		50 5 6
" Research Grant Money :		
Refund, balance 1912 Grant, to A. Young	1 14 3	
Sale of Lens to University of Cape Town	10 0 0	
		11 14 3
" Sale of Publications in 1922	121 17 6	
Plus : Amount due from Sale in 1922 ..	4 10 2	
	126 7 8	
Less : Refund of sale price of Transactions, £1 ; and purchase price of copies of Transactions, £15	16 0 0	
		110 7 8
		£798 9 5

Expenditure.

		£ s. d.	£ s. d.
By Publications :			
Cash paid for Publications to Adlard & Son and West Newman		327 6 2	
Cash paid for Publications to Neill & Co.		70 0 0	
		397 6 2	
Less : Contribution by A. W. Rogers to cost of L. F. Spath's Paper ..	£15 0 0		
Receipts for extra reprints of Papers, £8, 14s. 9d. ; *less* amount due for such from 1921, £8, 14s. 9d...	0 0 0		
Amount paid for 1921 Publications	252 10 3		
		267 10 3	
		129 15 11	
Plus : Balance, amount due to Neill & Co., for Vol. X, Pt. 3		76 14 11	
Estimated amount due to Neill & Co., for Vol. X, Pt. 4		170 0 0	
			376 10 10
" Compilation of International Catalogue of Scientific Papers			25 0 0
" Clerical Assistance and Work in Library..			65 0 0
" Local Printing and Stationery			54 6 6
" Postages and Petties			27 2 4
" Bank Charges for Commissions, Ledger Fee, Fixed Deposit Stamps, etc.		2 12 3	
Less : Commissions paid by Members		2 3 0	
			0 9 3
" Hire of Rooms and Caretaker, 1922.. ..			6 6 0
" Insurance of Library, 1922–23			0 10 6
" Profit in year 1922			243 4 0
			£798 9 5

ASSETS AND LIABILITIES AT DECEMBER 31, 1922.

Assets.*	£	s.	d.	Liabilities.				£	s.	d.
Money at Standard Bank on Fixed Deposit for one year at 4½ per cent.	500	0	0	Subscriptions, whole or in part, received for 1923 and 1924				8	14	0
Money in Savings Bank Department of Standard Bank	150	15	6	Publication of Transactions, estimated				246	14	11
Balance at Standard Bank, as per Pass Book	199	2	8	Binding Periodicals in Library				16	15	0
Union of South Africa 5 per cent. Stock (1921–36)	400	0	0	Earmarked for Expense of Publishing, as a part of the Transactions, a Reproduction of a Bushman Painting (Council Minutes, May 12, 1915), a sum not exceeding				350	0	0
Arrears of Subscriptions, as in Statement for 1921, £75, 19s.; *less* £60, 19s. paid in year 1922, and £4 struck off as irrecoverable	11	0	0	Balance from 1912 Conversazione carried forward towards the expenses of future Conversazione in Cape Town				7	4	0
Arrears of Subscriptions for 1922, £55; *less* £2 struck off as irrecoverable	53	0	0	Excess of Assets over Liabilities:						
				Amount at December 31, 1921	£445	16	5			
Account due for Sale of Publications	4	10	2	Add Profit in year 1922	243	4	0			
								689	0	5
	£1318	8	4					£1318	8	4

* Exclusive of value of Library and Publications of the Society held in Stock.

Entrance Fees and Life Subscriptions Fund.

	£	s.	d.		£	s.	d.
Amount of Fund at January 1, 1922	291	0	0	Amount of Fund at December 31, 1922	297	0	0
Entrance Fees received in 1922	6	0	0				
	£297	0	0		£297	0	0

We hereby certify that we have examined the above balance and revenue accounts with the books, vouchers, and Bankers' pass books relating thereto, and that, in our opinion, they correctly set forth a true and correct statement of the affairs of the Society.

W. N. ROSEVEARE.
ANDREW YOUNG.

February 16, 1923.

An Ordinary Meeting was held on Wednesday, April 18, 1923, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

Business :—

The Meetings of the previous Meeting were confirmed.

The following were nominated for Membership :—

Professor J. Smeath Thomas, D.Sc., proposed by the President, seconded by the Hon. General Secretary ; Dr. B. de C. Marchand, B.A., D.Sc., proposed by Dr. C. F. Juritz, seconded by Dr. L. Crawford ; Mr. Robert F. Lake, proposed by Dr. F. G. Cawston, seconded by the Hon. General Secretary ; Dr. P. J. du Toit, B.A., Ph.D., D. Med. Vet., Dr. H. H. Green, D.Sc., and Dr. P. R. Viljoen, D. Med. Vet., M.R.C.V.S., proposed by Sir Arnold Theiler, seconded by Dr. I. B. Pole Evans.

The following were elected to Membership :—

Mr. H. A. Storey, proposed by Dr. F. G. Cawston, seconded by Professor R. H. Compton ; Dr. A. Reith Fraser, M.D., proposed by Professor T. J. Mackie, seconded by the Hon. General Secretary ; Mr. D. J. Malan, B.Sc., proposed by Dr. D. E. Malan, seconded by Professor L. Crawford ; Dr. W. P. Mulligan, O.B.E., M.B., Ch.B., D.P.H., proposed by Professor T. J. Mackie, seconded by Dr. J. S. v. d. Lingen ; and Mr. F. B. Parkinson, proposed by Miss Wilman, seconded by Dr. J. Sutton.

The following communications were read :—

"Note on the Heterosomata (Flat-fishes) of South Africa," by C. von Bonde.

Some abnormalities are discussed which are occasionally found in pigmentation, scales, etc., of flat-fish generally, and in particular in new species described by the author.

"Some Notes on the Drought of 1922–23 on Table Mountain," by Thomas Stewart.

The first rainfall observations on Table Mountain were begun in January 1881, when a gauge was placed at a spot called Disa Head, the elevation of which above the sea-level is about 2500 feet. Additional gauges were fixed from time to time, until by the year 1900 there were eleven in all. The annual rainfalls for eight of these gauges up to 1922 inclusive, and the driest period of six months and seven months respectively at Disa Head and Waai Kopje stations, were given in appendices.

The average rainfall for thirty years on the highest portion of the mountain as deduced from the records of four gauges was about 75 inches.

The average for the same gauges for the last year was about 66¼ inches, and there were ten years of the thirty when the average was lower.

On no previous dry season has the precipitation at the station known as Waai Kopje (elevation 3100 feet)—which gives results for forty-two years—been so low as it has been for the seven months, September to March 1923, but there have been two periods when the amounts were under 3 inches higher.

If the Disa Head station is taken as indicating the conditions at the 2500 feet level, the dry seasons of 1883–84, 1919–20, and 1920–21 were drier than the last one.

"The Sulphide and Hydrosulphide of Ammonium," by J. Smeath Thomas (communicated by the President).

The author has previously shown that the polysulphides of the alkali metals can most easily be obtained in the pure and anhydrous condition by the action of sulphur on solutions of the hydrosulphides of these metals in dry alcohol.

The investigation here described, which was carried out in collaboration with Mr. R. W. Riding, M.Sc., arose from the application of this method to the preparation of polysulphides of ammonium. It thus became necessary to prepare alcoholic solutions of ammonium hydrosulphide. This substance has previously been investigated by Bineau and by W. P. Bloxam, and they also investigated the monosulphide. Their experiments were carried out either with gases or in aqueous solution; the properties of alcoholic solutions of these substances have not been described, and so far as the monosulphide is concerned it is highly probable that it has never been prepared.

Hence it seemed desirable to investigate these substances more fully, and more especially the behaviour of alcoholic solutions of them.

A detailed account of the work has been communicated to the Chemical Society of London, and will appear in their Transactions. The following is a summary of the results obtained:—

Ammonium hydrosulphide has been prepared by the action of hydrogen sulphide on alcoholic solutions of ammonia in large laminar crystals, which, however, always contained from 3 per cent. to 5 per cent. alcohol.

The anhydrous substance is most conveniently prepared by the action of hydrogen sulphide on solutions of ammonia in dry ether. By this method it is obtained in the form of long, needle-shaped crystals. These dissociate rapidly on exposure to the air. They are insoluble in ether and benzene, but dissolve readily in alcohol and in water, giving solutions which rapidly turn yellow owing to oxidation. From these solutions monoclinic crystals of sulphur are deposited, especially when the solution is heated. When air is excluded the alcoholic solution dissolves sulphur, and from the solution thus obtained ammonium pentasulphide is deposited.

It was found that by the action of hydrogen sulphide on alcoholic

solutions of ammonia at 0° C., solutions were obtained in which the ratio $\frac{[NH_3]}{[H_2S]}$ approximated to 1; that is to say, the solution consisted mainly of ammonium hydrosulphide. When the temperature was allowed to rise, however, the ratio had much higher values, and at 60° the value 1·98 was obtained, and this approximates very closely to the value theoretically required for ammonium monosulphide.

On precipitating these solutions by the addition of successive small quantities of ether saturated with ammonia, crystals were obtained having the composition $(NH_4)_2\ SC_2H_5OH$, but it was found impossible to remove the alcohol from this substance.

Ammonia reacts with ammonium hydrosulphide suspended in ether extremely slowly, but on the addition of a small quantity of alcohol a rapid reaction takes place and a heavy yellow oil separates, having the composition $(NH_4)_2\ S_2NH_3$. This substance is very unstable, but it is chiefly interesting on account of its extremely toxic properties.

When this oil is allowed to stand, transparent cubic crystals separate for which the ratio $\frac{[NH_3]}{[H_2S]}$ was found to be 2. The authors confidently believe this substance to be anhydrous ammonium monosulphide.

An Ordinary Meeting was held on Wednesday, May 16, 1923, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

Business:—

The Minutes of the previous Meeting were confirmed.

The following were elected to Membership:—

Professor J. Smeath Thomas, D.Sc., proposed by the President, seconded by the Hon. General Secretary; Dr. B. de C. Marchand, B.A., D.Sc., proposed by Dr. C. F. Juritz, seconded by Dr. L. Crawford; Mr. Robert F. Lake, proposed by Dr. F. G. Cawston, seconded by the Hon. General Secretary; Dr. P. J. du Toit, B.A., Ph.D., D. Med. Vet., Dr. H. H. Green, D.Sc., and Dr. P. R. Viljoen, D. Med. Vet., M.R.C.V.S., proposed by Sir Arnold Theiler, seconded by Dr. I. B. Pole-Evans.

Mr. G. V. Adendorff, B.Sc., proposed by Dr. L. Crawford, seconded by the President, was nominated for Membership.

Announcement was made of the candidature for Fellowship of Charles

MACDONALD STEWART, B.Sc.(Edin.), proposed by Dr. F. E. KANTHACK, Sir CARRUTHERS BEATTIE, Sir THOMAS MUIR, and Dr. A. YOUNG.

The following communications were made :—

" Notes on some South African Xylarias," by PAUL A. VAN DER BIJL.

Descriptions are given by the author of a number of species of Xylaria known to occur in South Africa.

" The Crystalline Structure of the Alkaline Sulphates," by A. OGG.

The author, in conjunction with Mr. LLOYD HOPWOOD (*Phil. Mag.*, Vol. XXII, p. 518), has shown by X-ray analysis of the alkaline sulphate, which form one of the best-known isomorphous series, that Pope and Barlow's Law of Valency volumes fails under this critical test.

It was shown that the *crystal unit* contains four molecules, but the complete structure was not worked out. It was suggested that to explain the X-ray spectra the sulphur atoms were placed at the corners of the unit rhomb and at the face centres. Attempts to get a similar structure to explain the X-ray spectra of all the sulphates have failed.

Molecules placed at the corners and face centres of the unit will explain the structure of ammonium sulphate crystals.

If we place the sulphur atoms at the corners and the face centres, with the nitrogen atoms at the centres of each of the eight rhombs into which the unit can be divided by planes through the centre of the unit at right angles to one another and parallel to the faces, we can build up a structure which satisfies the symmetry of the ammonium sulphate crystal, gives the correct dimensions, and satisfies the X-ray reflections.

The nitrogen atoms lie at the centre of a tetrahedron of hydrogen atoms, each hydrogen connecting up to an oxygen atom, which in turn connects up to a sulphur atom.

If we take W. L. BRAGG's values for the atomic diameters of nitrogen, oxygen, and sulphur, and 1 Ångstrom unit as the atomic diameter of hydrogen, as found by Sir W. H. BRAGG in organic crystals, the dimensions of the crystal unit is practically correct in all directions.

In the structure for potassium, rubidium, and caesium sulphates, if the metals with sulphur lie along the diagonal of the 100 face of the unit, the length of the diagonal, assuming Bragg's values for the atomic diameters, would be for K-S-K-S-K $= 2\ (4{\cdot}15 + 2{\cdot}05) = 12{\cdot}40$ Å, for Rb-S-Rb-S-Rb $= 2\ (4{\cdot}50 + 2{\cdot}05 = 13{\cdot}10$ Å, and for Cs-S-Cs-S-Cs $= 2\ (4{\cdot}75 + 2{\cdot}05) = 13{\cdot}60$ Å; while from X-ray measurements we find 12·45, 13·10, and 13·62. The substitution of rubidium and caesium for potassium gives the correct extension along this direction.

An Ordinary Meeting was held on Wednesday, June 20, 1923, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

Mr. G. V. Adendorff, B.Sc., proposed by Dr. L. Crawford, seconded by the President, was elected a Member.

The following communications were made :—

"Note on the Successive Differentiation of a Product of Linear Functions," by Sir Thomas Muir.

"The Differential Bactericidal Effect of the Visible Spectrum," by J. Steph. v. d. Lingen.

The author discussed the results of Bie, Marshall Ward, Downing, and Russ, and also those obtained by Bayne-Jones and himself. In the work of these investigators the technique was to expose a culture for a given time and then to incubate it for twenty-four hours or more. On the results of the incubation conclusions were drawn with regard to the bactericidal effect of the various regions of the spectrum.

The author then described a new method for studying the bactericidal effect. Filters were placed in front of a series of small boxes (chalk boxes) each of which contained four nutrient agar slopes. After inoculating the slopes with bacteria they were placed in the boxes, which fitted into an incubator. In front of the incubator rows of tungsten lamps were placed so that the distribution of light was uniform on the cultures. By adjusting the intensity of the light to a suitable value, the inhibitory and bactericidal effects of the various regions of the spectrum could be studied, as well as the effects of total illumination and total darkness.

Ps pyocyanea and *S. lutea* grow better in total light, blue-green, and total darkness than in any of the other fields, *i.e.*, red, yellow, and blue. The pigment of *Ps pyocyanea* and also that of *S. lutea* shows a corresponding bluish-green fluorescence in chloroform and alcohol respectively when excited by violet light. Further experiments are in progress on this subject.

"On the Attraction-coefficient for Substances of Low Critical Temperature," by John P. Dalton.

Some years ago the author found the dependence of van der Wall's "*a*" upon temperature for isopentane using Young's saturation data. He found that $a=a_K e\beta(T_K\text{-}T)$ within the reduced region $\theta=0{\cdot}6$ to $\theta=1$, but at the time sufficient saturation data were not available for testing this law of dependence for other substances. Since then the brilliant researches of Kamerlingh Onnes and his collaborators at Leiden have made available accurate saturation data for other substances of low critical temperature, and

their results have been used to determine the constants of the above relation for argon, oxygen, nitrogen, and hydrogen.

For these four substances a can well be represented as an exponential function of the temperature, and the agreement between the values of a calculated from the experimental data and those yielded by an equation of the type $\log a = \alpha - \beta T$ is very good.

The author finds that the exponential law of dependence of a upon T which was found for isopentane holds likewise for the substance now discussed, but that the product βT_{κ} deviates considerably from unity. It appears as if the coefficient β which is $-\frac{1}{a}\frac{da}{dT}$ may be termed the specific attraction temperature coefficient. β appears to diminish as the molecular weight of the substance increases.

The author further considers the value of β derived from the critical-pressure coefficients, and concludes that the values for the attraction coefficient deduced may be considered valid for the vicinity of the saturation regions.

"X-rays as a Means of Detecting Imperfections in Fruit," by C. W. Mally.

An effort to find an infallible means of detecting internal defects in export fruit led to a trial with X-rays. Radiographs reveal the internal structure in detail. The ensemble of sound fruit is harmonious, whereas defects cause conflicting shadows to appear in the radiograph.

The presence of fungal or bacterial organisms which produce decay is indicated in the radiographs by structural details being more or less obscure. This makes it possible in pathological research to determine with a great deal of certainty whether or not any given fruit that is to serve as a culture medium is sound, and also to record the progress of the organisms by mean of radiographs at regular intervals.

The practical application to fruit inspection depends on satisfactory visibility on the fluoroscopic screen being attainable.

An Ordinary Meeting of the Society was held on Wednesday, July 18, 1923, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

It was announced that the Council recommends Mr. Charles Macdonald Stewart, B.Sc., for election as a Fellow.

Dr. H. O. Moennig, M.A., Ph.D., and Dr. E. M. Robinson, D. Med. Vet., M.R.C.V.S., proposed by Professor D. E. Malan, seconded by Professor L. Crawford, were nominated for Membership.

The following communications were made :—

"On a Proposed Modification of the Cathode Ray Oscillograph," by E. Newbery.

The author describes a modification of the oscillograph devised by him which will fit the instrument better for the study of over-voltages.

"Note on the Polysulphides of Ammonium, with some considerations regarding the constitution of the Polysulphides of the Alkali Metals," by John Smeath Thomas and Richard William Riding.

The action of sulphur on solutions of ammonium hydrosulphide in dry alcohol has been investigated. The reaction was found to result in the formation of ammonium pentasulphide only. Attempts to prepare lower polysulphides by this method were unsuccessful, and it would appear that, as in the case of sodium and potassium, the tendency is for one polysulphide to be formed in greatly predominating amount. In the case of sodium this polysulphide is the tetrasulphide, in the cases of potassium and ammonium the pentasulphide.

No evidence has been obtained of the existence of the enneasulphides described by Bloxam (*Trans. Chem. Soc.*, 1895, lxvii, 277), and in view of the close resemblance between the ammonium and the potassium polysulphides the existence of these compounds is extremely doubtful. Unfortunately, the instability of the ammonium compounds precludes the application to them of the thermo-analytical method employed by Thomas and Rule (*Trans. Chem. Soc.*, 1917, cxi, 1063) to determine whether similar compounds existed in the sodium and the potassium series.

Ammonium pentasulphide resembles sodium tetrasulphide and potassium pentasulphide in that its alcoholic solutions are capable of dissolving still more sulphur. At 25° sulphur is taken up to an extent represented by the formula $(NH_4)_2\ S_{6\cdot17}$. Increase of temperature exerts only a small influence on this ratio. This appears to indicate that the power of the sulphur complex to combine with sulphur is still not completely satisfied. However, if higher compounds exist in the solution they are unstable ; for on attempting to crystallise them decomposition occurs, whilst a similar decomposition results on the addition of water, sulphur being precipitated. It is possible that the ordinary valency relations do not exist beyond the pentasulphide, and that in taking up further quantities of sulphur the residual affinity of the sulphur complex is brought into play. There is evidence, however, of the existence of higher polysulphides, and a heptasulphide has been isolated by a slightly modified method.

Pyridine and nitrobenzene were found to react with ammonium pentasulphide in a manner similar to the action of these solvents on the polysulphides of sodium, potassium, and rubidium. Highly coloured solutions were obtained in this way, the probable explanation being that unstable additive compounds are formed.

During the decomposition of the pentasulphide in air the colour of the substance changed from yellow to red. This change was accelerated by traces of ammonia and especially of moisture, whilst the passage of dry air over the red crystals rapidly converts them into the yellow form. This colour change may be due to the existence of ammonium pentasulphide in two modifications, but the authors incline to the view that the phenomenon is due to the formation of the heptasulphide as an intermediate stage in the decomposition of the pentasulphide.

When ammonium pentasulphide is heated in a sealed tube ammonium disulphide is formed which condenses in the cold portions of the tube. It is also formed, though in an impure state, when mixture of carbon disulphide and ammonium pentasulphide are distilled and when solutions of the pentasulphide in alcohol are boiled in a rapid stream of hydrogen.

The bearing of this reaction on the constitution of the polysulphides is of especial interest. In a previous communication (*Trans. Chem. Soc.*, 1917, cxi, 1063) the views put forward by various workers regarding this question have been examined and reasons were given for preferring the general formula $R_2S_2S_x$ suggested by Spring and Demarteau (*Bull. Soc. Chem.*, i, 11) to the formula R_2SS_x advocated by Küster and Heberlein (*Zeit. anorg. Chem.*, 1905, xliii, 72). The evidence then adduced pointed to the existence in the polysulphide molecule of two sulphur atoms in a different state of combination from the remainder, and in order to obviate the objections of Küster and Heberlein it was suggested that the disulphides should be regarded as being derived from a form of hydrogen disulphide represented by the formula H.S.S.H. Higher polysulphides are then formed by the addition of sulphur to the disulphides, compounds of the type

$$\underset{\underset{S}{\|}}{\text{R.S.S.R.}},\quad \text{R.}\underset{\underset{S}{\|}}{\text{S}}.\underset{\underset{S}{\|}}{\text{S}}\text{.R.},$$

etc., being thus obtained.

This view is entirely confirmed by the decomposition of ammonium pentasulphide into the disulphide and free sulphur. The reaction takes place at a low temperature and is quantitative in character. It proves beyond doubt that two sulphur atoms in the molecule are differently combined from the remainder.

The properties of the ammonium polysulphides and the full experimental details regarding their preparation have been described in the *Transactions of the Chemical Society*, 1923, cxxiii.

"The Active Principle of Homaria Pallida (Yellow Tulp)," by M. Rindl.

The author has succeeded in extracting from this plant an active principle having digitalis-like physiological effects.

An Ordinary Meeting of the Society was held on Wednesday, August 15, 1923, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

The following were elected to Membership: Dr. H. O. Moennig, M.A., Ph.D., and Dr. E. M. Robinson, D. Med. Vet., M.R.C.V.S., proposed by Professor D. E. Malan, seconded by Professor L. Crawford.

The President announced that, in accordance with the resolution passed at a previous meeting expressive of the great loss sustained by the Society through the death of Mr. S. S. Hough and of the Society's sympathy with Mr. Hough's relatives, he had written to Mr. Hough's brother. A letter has been received from Mr. W. N. Hough in the following terms: "I desire to express to you my very sincere thanks for your kind message of sympathy on the loss of my brother. We are greatly appreciative of the many expressions of regret at the loss of an astronomer of knowledge and ability, but what we most appreciate is the assurance that he had a place in the hearts of those with whom he was associated in his scientific work. Once again I thank you, and through you the Royal Society of South Africa, for your kindly and sympathetic message."

The following communications were made :—

In the absence of Dr. J. D. F. Gilchrist his Note on a Protozoal Parasite of the Snoek was held over until the next Meeting.

"Preliminary Note on the Active Principles of the Yellow Tulp (Homeria pallida)," by M. Rindl.

The investigation was carried out at the Imperial Institute with material collected in the Lichtenburg district by officers of the Department of Agriculture. Its toxicity was established by feeding tests at the Laboratory for Veterinary Research at Onderstepoort.

The bulk extraction of the overground portion with alcohol was undertaken by the British Drug House at the request of the authorities of the Imperial Institute.

The extract, after removal of the solvent, was separated into a water soluble portion and into a resin. The latter was reserved. The former,

after purification, yielded crude alkaloid equivalent to 0·107 per cent. calculated on the weight of the plant material. Only 23 per cent. of this is water soluble, and it appears as if the stems and leaves owe their toxic properties mainly, if not entirely, to this water soluble alkaloid. Physiological tests carried out by Professor W. E. Dixon, F.R.S., show that this alkaloid exerts a digitalis-like action on the circulation. In large doses the alkaloid is a cardiac poison. Its action is not cumulative, so that successive small doses can be administered to animals intravenously without hurting them. These results are interesting, because only one other alkaloid with a digitalis-like action (erythropleine) is on record.

Attempts to obtain the alkaloid or some of its derivatives in a crystalline form have so far proved unsuccessful.

In addition to the alkaloid just referred to, the aqueous solution appears to contain two other alkaloids differing in their behaviour towards organic solvents, as well as an organic base. Endeavours were made to isolate these substances in a pure form, and to characterise them chemically, but these have only proved partially successful. The presence of a primary amine was also established, but it could not be identified. There are also indications of the presence of a very small amount of a glucoside.

Extracts from the corms and sheaths were also examined physiologically. They contain active substances of the nature of what is usually termed a cardiac tonic. They are very poisonous, and are more closely related in action to squill than to digitalis or strophanthus. Administered to animals in successive small doses they send the heart into fibrillation and cause sudden death.

Annual Meeting.

The Annual Meeting was held on Wednesday, September 26, 1923, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

Business :—

Mr. Charles Macdonald Stewart, B.Sc., was elected a Fellow.

Ordinary Meeting.

An Ordinary Meeting was held after the Annual Meeting.

The President was in the Chair.

Business :—

The Minutes of the last Ordinary Meeting were confirmed.

Demonstration :—

" Of the Form of the Benzene Ring as shown by the Crystal Structure of Naphthalene and Anthracene," by Dr. A. Ogg.

Considering the importance of the benzene ring in organic chemistry, this demonstration was given to elucidate the crystalline structure of the benzene ring from the measurement of Sir W. H. Bragg (*Proc. Phy. Soc.*, London, Vol. xxxiv, Dec. 1921, and Vol. xxxv, April 1923). Models constructed with relative atomic dimensions were shown to illustrate the structure. Starting with the diamond which has a cubic unit of side $3{\cdot}55 \times 10^{-8}$ cm. containing 8 atoms, the tetrahedron arrangement of the carbon atoms was demonstrated, and also the arrangement of 6 carbon atoms not in one plane, to form a benzene ring.

X-ray measurements show that the crystal units of naphthalene and anthracene each contain two molecules, and have practically the same dimensions except along the C axis. An addition of a benzene ring adds approximately $2{\cdot}5 \times 10^{-8}$ cm. to the C axis. The models show that there are two kinds of hydrogen atoms, one set link on to neighbouring molecules through carbon atoms, and the other through hydrogen atoms. The natural cleavage of the crystal is perpendicular to the C axis along the union of hydrogen with hydrogen.

The following communications were made :—

" On a Protozoal Parasite of the Snoek—Chloromyxum thyrsites, sp. n." by J. D. F. Gilchrist.

1. The Cape " Snoek " and the Australian " Barracouta " (*Thyrsites atun*) show a softening or liquefaction of the muscular tissue, caused by a protozoal parasite resembling Chloromyxum.

2. The spore is quadriradiate, about 12×8 microns, has four polar capsules, and only four distinct nuclei were seen.

3. The trophozoite is unicellular, increasing by schizogeny or simple fission and is usually intercellular.

4. Each trophozoite produces a single spore.

" Note on Cathode Ray Absorption." by B. F. J. Schönland.

The author has shown that the theory of absorption due to Bohr is in good quantitative agreement with new measurements of the absorption of cathode rays by matter.

In applying the theory to measurements of the decrease in velocity of rays in passing through matter, Bohr has deduced the relation $(V_0 - V)V_0^3 = ct^{(1)}$ where—

V_0 = initial velocity,
V = final velocity,
t = thickness,
c = constant.

Existing measurements have all been put in the form—

$$V_0^4-V^4=Kt \quad . \quad . \quad . \quad (2)$$

It is shown that by simple factorisation of the left-hand side this last equation reduces to Bohr's form in the case where V and V_0 are nearly equal. Recent measurements by Terrill (*Phys. Rev.*, July 1923), which are put in the form of equation (2), are shown also to satisfy (1). The value of c for aluminium deduced from Terrill's observations is $4{\cdot}0{\cdot}10^{42}$, while that calculated from Bohr's theory is $4{\cdot}1{\cdot}10^{42}$.

"On Matrices connected with Sylvester's Dialytic Eliminant," by JOSEPH KÜRSCHÁK, Budapest (communicated by Sir THOMAS MUIR, F.R.S.).

"South African Spiders," by R. F. LAWRENCE.

The demonstration was of a nature to show the diverse forms taken on by different genera of the group of Argropid spiders for the purpose of protective resemblance and warning colouration.

Specimens of the well-known genus "gasteracantha" were shown with some of the less-known genera "Paraplectana" and "Pycnocantha."

A tropical form, "Nephila," is of interest owing to several attempts in Madagascar to put the silk of this spider to industrial uses. This spider is also largely found throughout Rhodesia and along the east coast of South Africa.

An Ordinary Meeting of the Society was held on Wednesday, October 17, 1923, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. OGG, was in the Chair.

Business :—

The Minutes of the last Ordinary Meeting were confirmed.

Professor R. S. ADAMSON, M.A., B.Sc., proposed by Professor R. H. COMPTON, seconded by the Hon. General Secretary, was nominated for Membership.

The Hon. General Secretary announced the Council's recommendation for Officers and Council for 1924 as follows :—

Members of Council.—Messrs. K. H. BARNARD, J. W. BEWS, W. A. CALDECOTT, L. CRAWFORD, J. P. DALTON, W. A. JOLLY, C. W. MALLY, A. OGG, L. PÉRINGUEY, I. B. POLE EVANS, J. S. v. D. LINGEN, and A. YOUNG.

Officers.—President, Dr. A. OGG ; Hon. Treasurer, Dr. L. CRAWFORD ; Hon. General Secretary, Dr. W. A. JOLLY.

Demonstration :—

"Of an Example of Adaptation in a South African Isopod Crustacean," by K. H. Barnard.

Specimens of the reef-building Polychaet worm, *sabellaria capensis*, were first exhibited, and some remarks made on the fauna which is found among the crevices of these reefs and in the empty worm-tubes themselves. One of the most interesting inhabitants of these tubes is an Isopod Crustacean, allied to *Eisothistos*. This animal has evolved an elongate worm-like shape in strong contrast to the other members of the Isopoda. The "tail-fan," on the other hand, is greatly enlarged, and when fully expanded fits the mouth of the worm-tube exactly, forming a door completely blocking the entrance to the tube. The mechanism of the tail-fan was explained.

The following communications were made :—

"The Volcanic Rocks South of Zuurberg," by S. H. Haughton and A. W. Rogers.

This paper describes the field occurrences and relationships of certain strips of volcanic and associated rocks in the divisions of Steytlerville, Uitenhage, and Alexandria. The rocks are shown to extend through an area about 100 miles in length from east to west along the northern boundary fault of the Cretaceous beds and are continued southwards round the western end of the Cretaceous area, following it again towards the east on its southern side for 23 miles. The folded belt of rocks belonging to the Cape System and lower part of the Karroo System forms an incomplete "frame" defined by faults on the north, west, and partly on the south, within which there is a sunken area. This area consists of Cretaceous rocks lying unconformably upon an uneven surface of marls, sandstones, sandy tuffs, breccias, and basalts. This latter post-Ecca, pre-Cretaceous formation forms a syncline of post-Uitenhage date, and is unaffected by the intense folding and cleavage of the surrounding region. It seems probable that this formation can be correlated with part of the Stormberg series. The structure of the down-faulted area recalls that of the sunken areas of post-Uitenhage age described by Professor Schwarz in the country to the west.

Short descriptions are given of sections of some of the sandy tuffs and basalts.

"Studies in the Morphology of Selaginella Pumila, Part III.—The Embryo," by A. V. Duthie.

The megaspores of *Selaginella pumila*, which are shed towards the end of the year, lie dormant on the soil during the summer months and germinate after the early winter rains. In laboratory cultures the first sporophytes were observed twenty-six days after the sowing of the spores, and sporophytes continued to appear for some seven weeks.

There is evidence to show that intra-sporal embryos can endure prolonged drying without losing their vitality. A striking feature of the embryo is the prominent foot with large haustorial cells which project into the non-septate storage cavity of the megaspore. The cotyledons do not develop simultaneously, nor are they strictly opposite each other. The first dichotomy of the axis, which takes place at the level of the cotyledons, gives rise to two branches which differ strikingly in size and behaviour. The one grows erect, the other develops into a very short horizontal rhizome which produces a series of branches alternately right and left. The number of cones found on adult plants varied from 1 to 160. The sporophytes are greatly modified by conditions of environment. Numerous examples of anisophylly, the result of one-sided illumination, have been observed.

S. pumila has been found to possess a number of characters which are very suggestive of the tree-like Lycopods of the Palaeozoic. Some of these characters may also be interpreted as the result of adaptation of a plastic species to its environment.

The closest relative of *S. pumila* is the Australian species, *S. Preissiana*, with which a brief comparison is made in the paper.

"On the Genesis of Diamond," by J. R. SUTTON.

This paper consists of statistics and observations which, in the author's opinion, go far to prove that the various known forms of diamond are attributable to growth only, and that the hypothesis of partial solution creates more difficulties than it removes. There is no foundation for the idea that diamond crystallised in a free space in which it could develop, or dissolve, freely in all directions equally. Crystallisation was not necessarily at a high temperature, and may have been preceded by a condition of plasticity in the carbon. Diamond was deposited from a carbon solvent within cavities, whose contour determined its final form and habit, in a solid or solidifying matrix.

"On the Action of some Fluorescent Antiseptics in the Dark" (preliminary Note), by J. S. v. D. LINGEN.